The INSTITUTION *of* PRODUCTION ENGINEERS

JOURNAL

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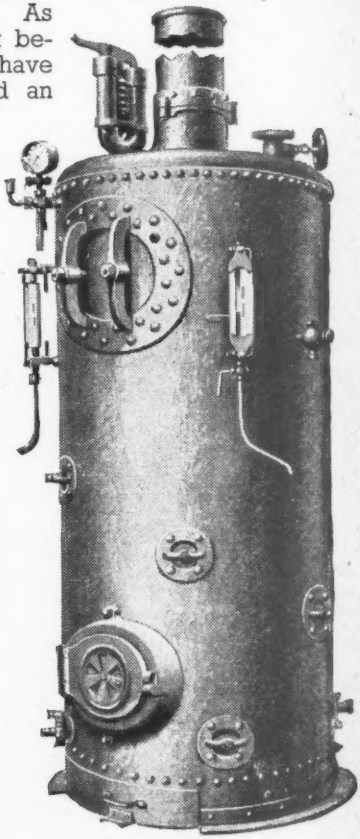

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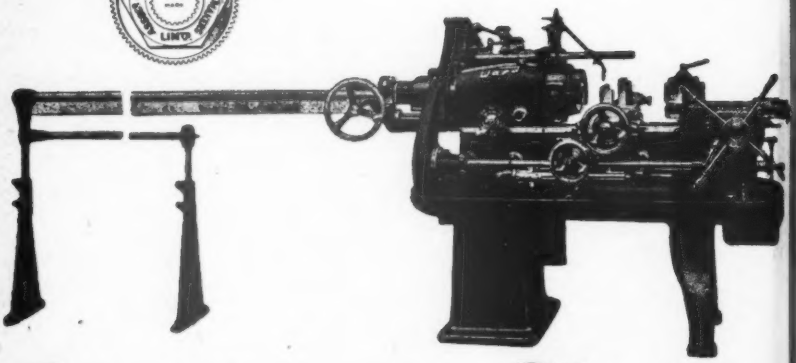

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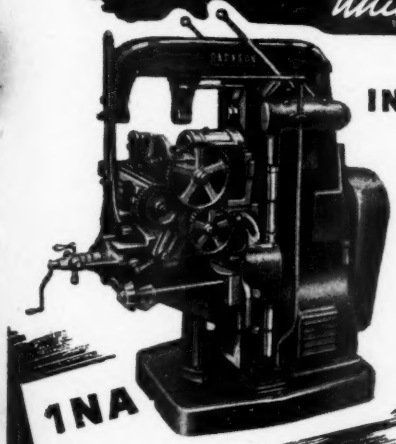
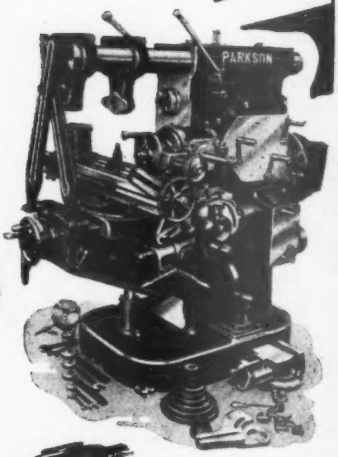


1NA

2T



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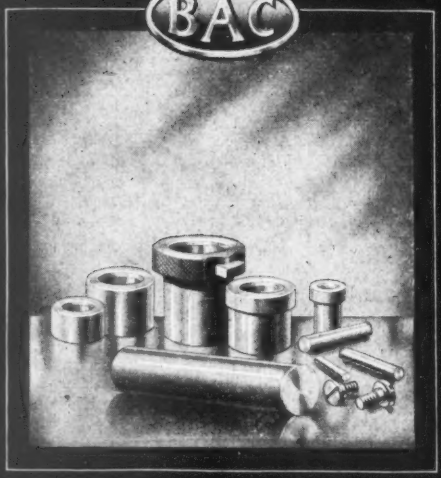

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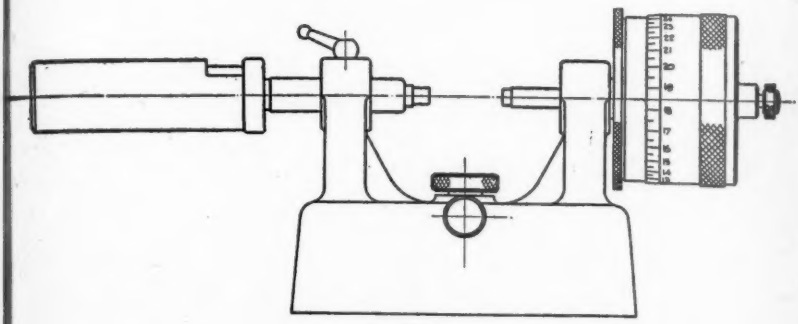

No. 1110

REF. 1000.—HORIZONTAL PROJECTORS
REF. 1010.—VERTICAL PROJECTORS FOR SCREWS
REF. 1020.—SCREW PITCH MEASURING MACHINES
REF. 1030.—SCREW DIAMETER MEASURING MACHINES
REF. 1070.—AUTO COLLIMATORS
REF. 1071.—ALIGNMENT TELESCOPES AND COLLIMATORS
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REF. 1120.—TAPER DIAMETER MEASURING MACHINES

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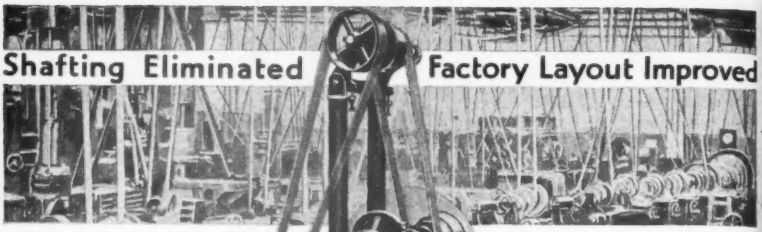

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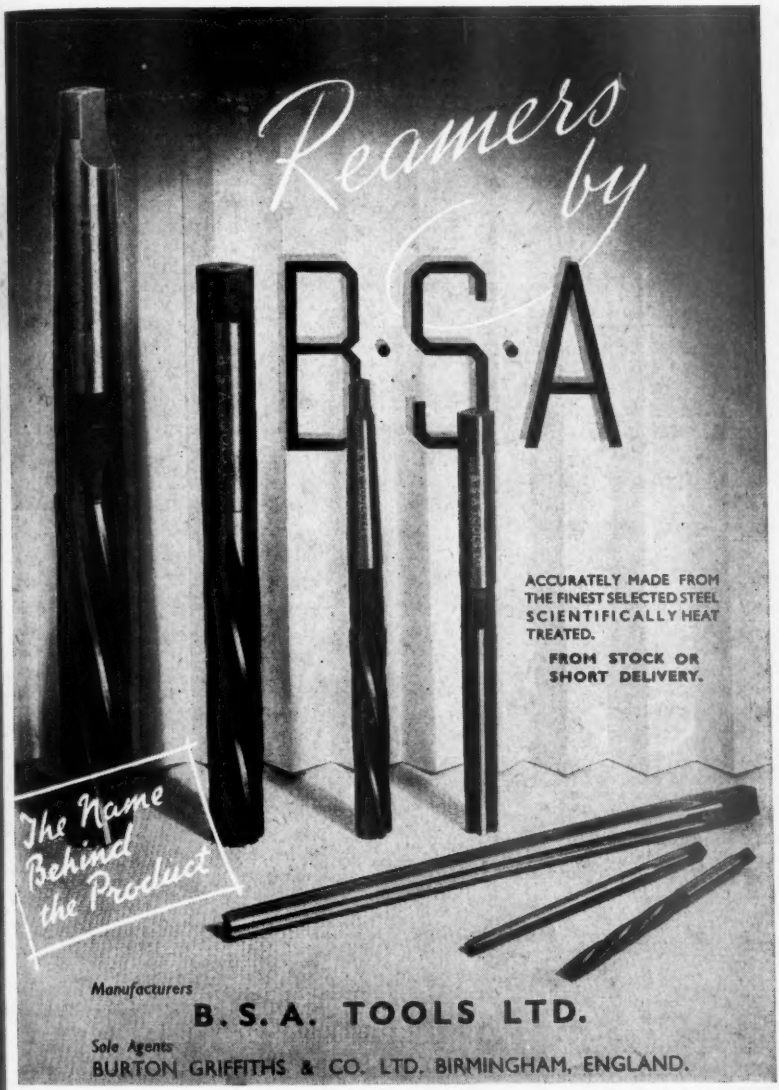
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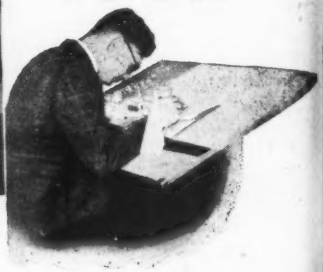
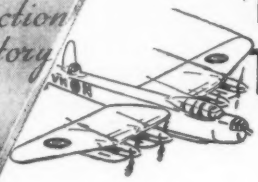


Production for Victory



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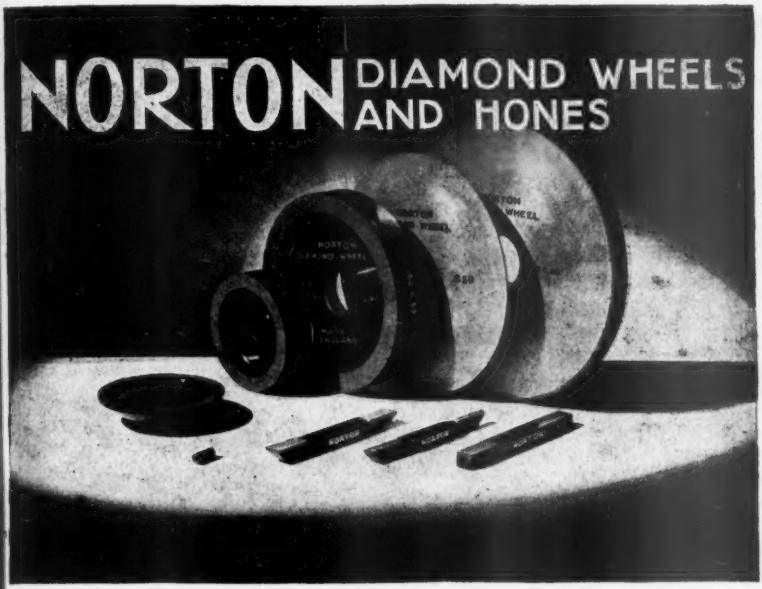

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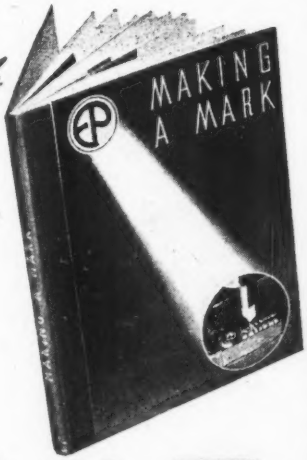

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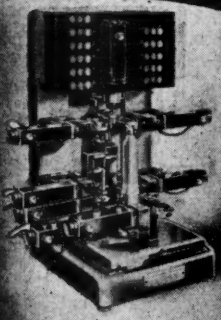

This electrical visual indicator is designed for checking components to predetermined limits. Micrometer screw allows independent setting of plus and minus limits. Amber signal light shows job above set limits, red shows work below, and green shows work within limits. Illustrations above show the indicator as a bare unit and also mounted on a suitable stand.

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Illustration at left shows how combinations of signal indicators can be used in multi-checking fixtures with remote indicator panels.

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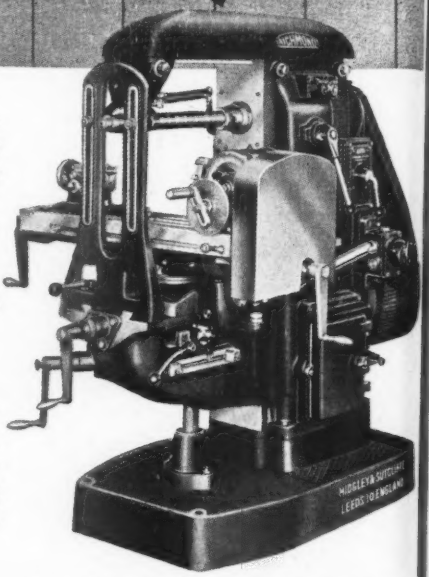
03 SD UNIVERSAL MILLING MACHINE



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SPEEDS (8) Range... ...	20—375
H.P. of Motor	3

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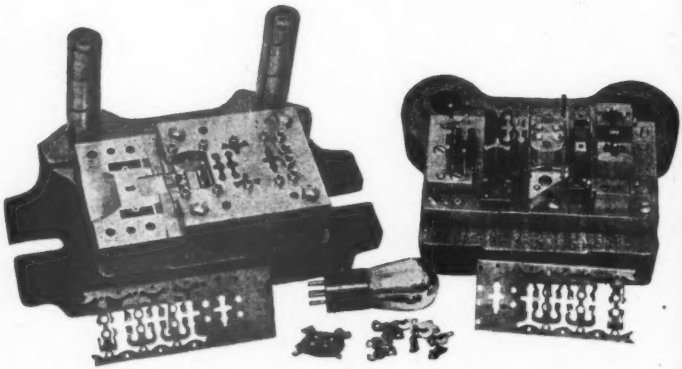

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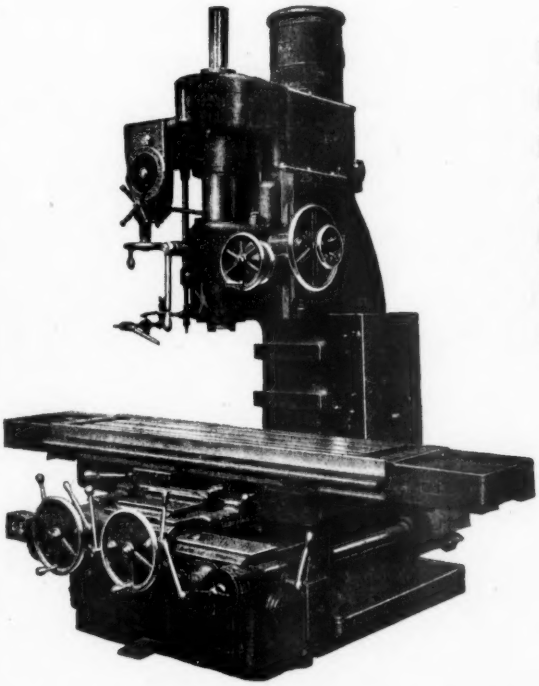

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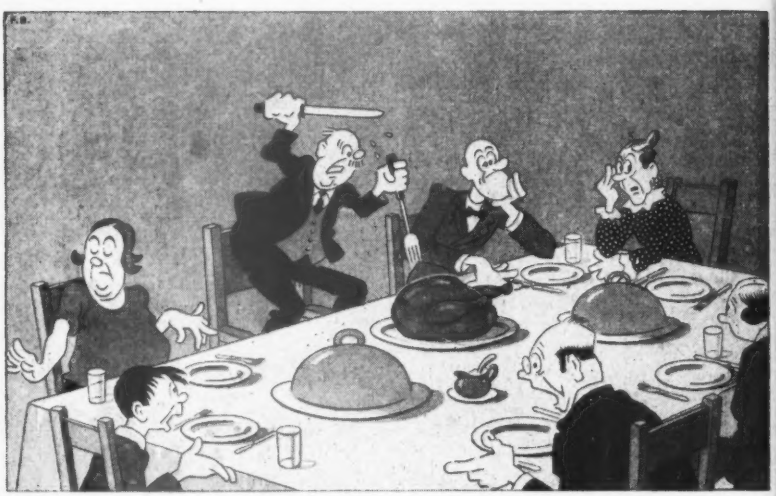

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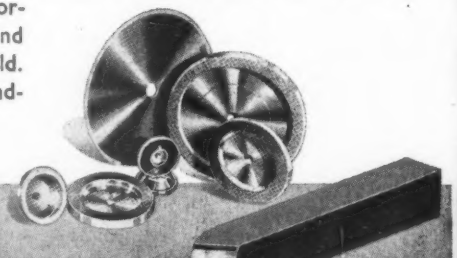

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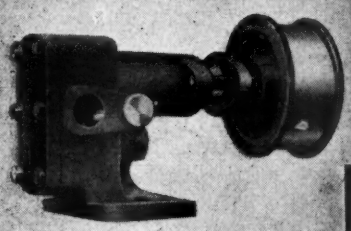
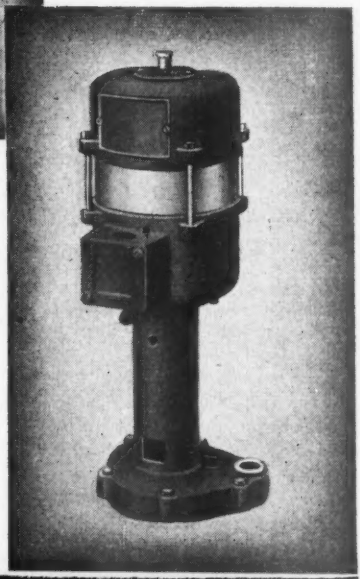


No.	Branches	G.P.M.	Speed
1	$\frac{3}{8}$ in.	96	400
2	$\frac{1}{2}$ in.	152	400
3	$\frac{3}{4}$ in.	304	300



No.	Motor B.H.P.	Capacity G.M.P.	Head in Feet	Outlet BSS
1	$^1/_2$	25	12	1 in.
2	$^1/_5$	8	10	$\frac{1}{2}$ in.
3	$^1/_{10}$	5	6	$\frac{1}{2}$ in.

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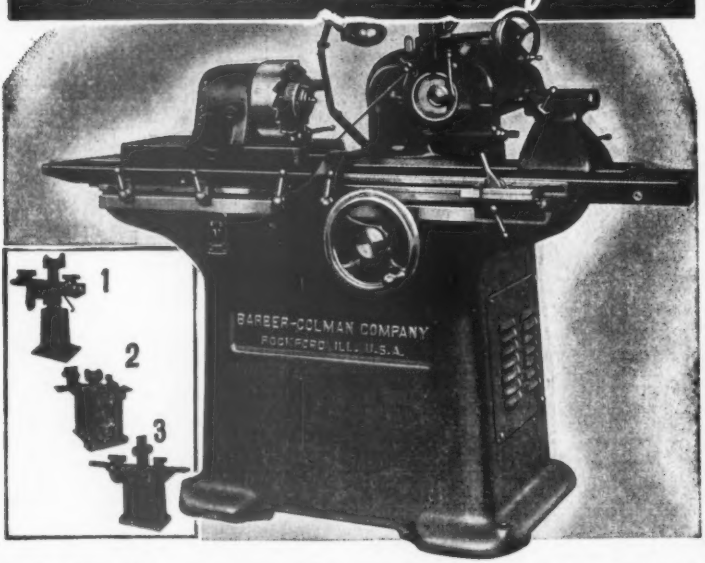

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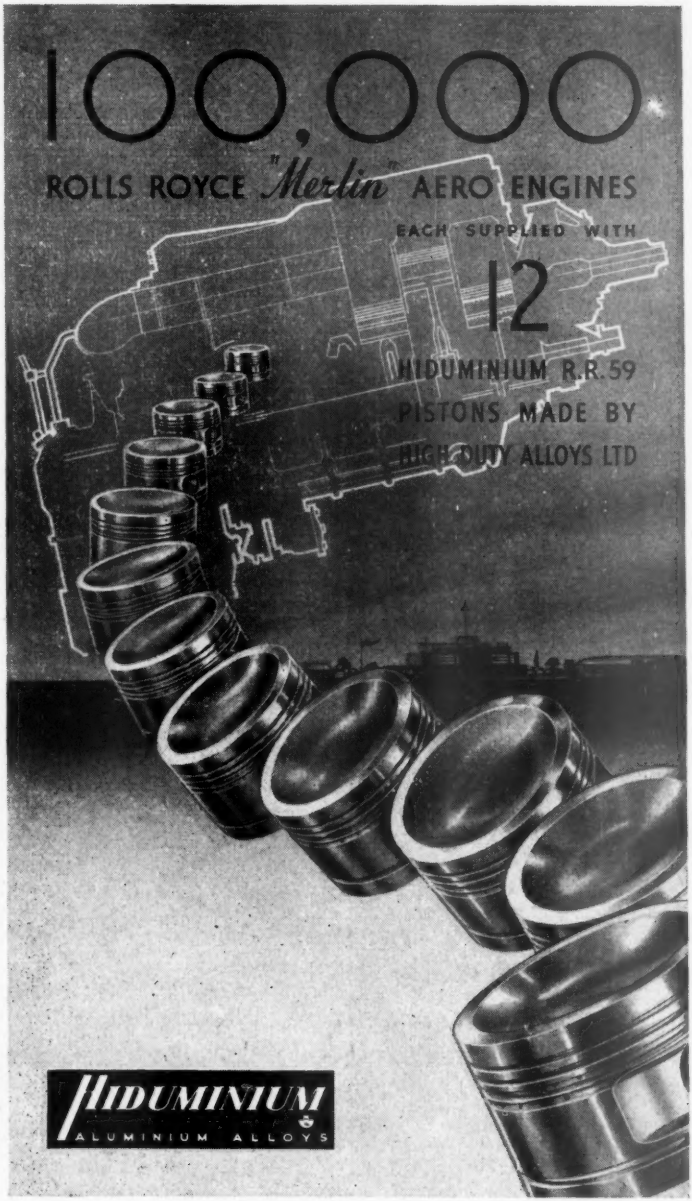
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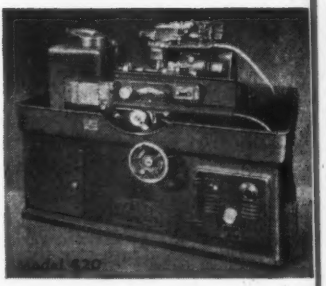

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The fact that goods made of raw materials in short supply owing to war conditions are advertised in "The Journal" should not be taken as an indication that they are necessarily available for export.

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1944-5

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Loughborough College : T. D. Walshaw, B.Sc., Loughborough College, Loughborough, Leics.

INSTITUTION NOTES

November, 1944

1944

December Meetings.

1st Leicester Section. B. P. Cooper, Esq., M.I.Mech.E. will lecture on "Apprenticeship Training," at the Leicester College of Technology at 7-0 p.m.

2nd Manchester Section. H. Eckersley, Esq., M.I.P.E., will lecture on "Negative Rake Milling Cutters," at Liverpool University at 2-30 p.m.

9th North Eastern Section. Social Evening to be held at the Stuart Restaurant, Team Valley Trading Estate at 6-30 p.m.

9th Manchester Section. Works visit to Geo. Richards & Co. Ltd., Broadheath, Nr. Manchester at 2-15 p.m.

11th Coventry Graduate Section. Wing-Commander Cave-Brown-Cave will address a joint meeting with the Institutions of Mechanical Engineers and Automobile Engineers at the Coventry Technical College, at 6-30 p.m.

13th Sheffield Section. A Hodgson, Esq., M.I.P.E., will lecture on "Quality Control in Steel Works, with particular reference to Precision Cold Rolling," at the Royal Victoria Hotel, Sheffield, at 6-30 p.m.

15th Leicester & District Section. Dr. Roxbee Cox will lecture on "Aeronautical Development," at the Leicester College of Technology, The Newarks, Leicester, at 7-0 p.m.
(Joint meeting with the Leicester Association of Engineers.)

15th Nottingham Section. J. A. Metcalf, Esq., will lecture on "Production of Coal for the Market," at Lincoln Technical College, at 7-0 p.m.

16th Yorkshire Graduate Section. E. Dalby, Esq., A.I.P.E., will lecture on "Efficient Stores Control," at the Great Northern Hotel, Leeds, at 2-30 p.m.

16th Wolverhampton Section. E. W. Hancock, M.B.E., will lecture on "The time Factor in Industry," at the Dudley and Staffordshire Technical College, at 6-30 p.m.

21st Glasgow Section. J. McFarlane, B.Sc., M.I.P.E., will lecture on "Gauge Making in War Time," at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2., at 7-15 p.m.

31st Luton, Bedford & District. A meeting has been arranged at the Central Library Meeting Room, George Street, Luton, at 10-0 a.m. Details to be arranged later.

1945.

January Meetings.

4th Leicester & District Section. Dr. D. F. Galloway will lecture on "Production Engineering Research," at the Leicester College of Technology, Leicester, at 7-0 p.m.

8th Coventry Graduate Section. E. B. Wall, Grad.I.P.E., will lecture on "Wage Incentive Systems," at the Coventry Technical College (Room A5), at 6-30 p.m.

18th Glasgow Section. F. G. Hewitt, Esq., will lecture on "General Survey of the Production of High Tensile Steel Wire and Wire Ropes" at The Institute of Engineers & Shipbuilders, Glasgow, C.2., at 7-15 p.m.

19th Eastern Counties Section. E. C. Cousins, Esq., will lecture on "Plastics" at the Lecture Hall, Electric House, Ipswich, at 7-0 p.m.

20th Halifax Section. A. Sykes, Esq., M.I.P.E., will lecture on "Developments in Gear Cutting and Finishing Processes," at the Technical College, Hopwood Lane, Halifax, at 2-30 p.m.

24th Wolverhampton Section. C. A. J. Taylor, M.Sc., A.R.I.C., will lecture on "Some Aspects of Modern Industrial Coatings and Post-War Synthetic Finishes," at the County Technical College, Wednesbury, at 6-30 p.m.

24th Manchester Section. R. Whibley, Esq., will lecture on "Some Aspects of Modern Precision Grinding," at the College of Technology, Manchester, at 7-15 p.m.

25th North Eastern Section. T. B. Maddison, A.M.I.P.E., will lecture on "Production Methods in Railway Shops," at Melville Hall Mining Institution, Newcastle-on-Tyne, at 6-15 p.m.

26th Coventry Section. G. Parr will lecture on "The Future of Television," at the Coventry Technical College, at 6-30 p.m.

26th Manchester Section. R. Whibley will lecture on "Some Aspects of Modern Precision Grinding," at the Mechanics Institute, Crewe, at 7-15 p.m.

28th Luton, Bedford & District. George B. Tinker will lecture on "Electric Furnace Brazing," at the Central Library Meeting Room, George Street, Luton, at 10-0 a.m.

31st Cornish Section. W. A. Cook, will lecture on "The Utility of Plastics to the Engineer," at Camborne School of Mines, at 7-15 p.m.

February Meetings.

1st Leicester & District Section. W. Swift, will lecture on "Negative Rake Milling" at the Leicester College of Technology, at 7-0 p.m.

February Meetings—*continued.*

3rd Manchester Section. R. Whibley will lecture on "Some Aspects of Modern Precision Grinding," at the Liverpool University, at 2-30 p.m.

6th North Eastern Graduate Section. Discussion Evening on Production Brains Trust, at Melville Hall Mining Institution, Newcastle-on-Tyne, 6-15 p.m.

12th Coventry Graduate Section. Any Questions Evening at The Coventry Technical College, Room A5, at 6-30 p.m.

15th Glasgow Section. Brains Trust, at The Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, at 7-15 p.m.

22nd North Eastern Section. Open at the Melville Hall Mining Institution, Newcastle-on-Tyne, at 6-15 p.m.

23rd Coventry Section. Dr. D. F. Galloway will lecture on "Production Engineering Research," at the Coventry Technical College.

25th Luton, Bedford & District. H. C. Town will lecture on "Hydraulics as Applied to Machine Tools," at the Central Library Meeting Room, George Street, Luton, at 10-0 a.m.

28th Cornish Section. W. G. Morgan will lecture on "Modern Foundry Practice," at the Camborne School of Mines, at 7-15 p.m.

28th Manchester Section. S. C. Roberts will lecture on "Costing as Applied to Production," at the College of Technology, Manchester, at 7-15 p.m.

March Meetings.

1st Leicester & District Section. T. G. Pearcey, F.G.W.A. will lecture on "Financial Management of Small Engineering Firms" at the Leicester College of Technology, at 7-0 p.m.

6th North Eastern Graduate Section. J. W. Pringle, Grad.I.P.E. will lecture on "Measurement and Control of Temperature in Furnaces," at Melville Hall Mining Institution, Newcastle-on-Tyne, at 6-15 p.m.

10th Halifax Section. T. P. N. Burness, M.I.P.E., will lecture on "Production Methods as Applied to Machine Tools," at the Huddersfield Technical College, at 2-30 p.m.

12th Coventry Graduate Section. A meeting has been arranged at the Coventry Technical College, Room A5, at 6-30 p.m. (Details to be announced later.)

15th Glasgow Section. A. C. McDonald, B.Sc., will lecture on "Modern Heat Treatment," at The Institute of Engineers and Shipbuilders, Glasgow, C.2., at 7-15 p.m.

March Meetings.—*continued.*

16th Manchester Section. H. W. Inshaw will lecture on "Advantages of Using Plastics ," at The Mechanics Institute, Crewe, at 7-15 p.m.

16th Eastern Counties Section. Lecture on " Jig and Tool Symposium," at the Lecture Hall, Electric House, Ipswich, at 7-0 p.m.

21st Manchester Section. G. Goddard will lecture on " Machining Light Alloys," at The College of Technology, Manchester, at 7-15 p.m.

22nd North Eastern Section. L. Walker, M.I.P.E., will lecture on " Heavy Machine Tools," at the Melville Hall Mining Institution, Newcastle-on-Tyne, at 6-15 p.m.

23rd Coventry Section. A. G. Askew will lecture on " Modern Gear Production," at the Coventry Technical College, at 6-30 p.m.

24th Manchester Section. W. Puckey, M.I.P.E., will lecture on " Management in Action," at the Liverpool University, at 2-30 p.m.

25th Luton, Bedford & District Section. R. C. Fenton will lecture on " Negative Rake Milling," at the Central Library Meeting Room, Luton, at 10-0 a.m.

28th Cornwall Section. Dr. D. F. Galloway, B.Sc., will lecture on " Production Engineering Research," at the Camborne School of Mines, at 7-15 p.m.

April Meetings.

5th Leicester and District Section. The Annual General Meeting will be held at Leicester College of Technology, at 7-0 p.m.

25th Manchester Section. W. D. Jones will lecture on " Powder Metallurgy," at The College of Technology, Manchester, at 7-15 p.m.

27th Coventry Section. Annual General Meeting will be held at Coventry Technical College.

29th Luton, Bedford and District Section. Dr. D. F. Galloway will lecture on " Machine Tool Research and Development," at The Central Library Meeting Room, George Street, Luton, at 10-0 a.m.

May Meetings.

11th Eastern Counties Section. Brains Trust, will be held in the Lecture Hall, Electric House, Ipswich, at 7-0 p.m.

North Eastern Section. General Meeting and Works Visit to Messrs. Noble & Lund, at the Melville Hall Mining Institution, Newcastle-on-Tyne. Date to be announced later.

Resignation of Dr. Fenelon.

We have to announce that Dr. Fenelon has intimated that he wishes to resign from the Secretaryship of the Institution ; this has been agreed to, and will take effect as at the 31st January, 1945.

At the Council meeting on 6th October, a special committee of Council was elected by secret ballot to deal with the appointment of a new General Secretary and further, to report back to Council their views as to what re-organisation could with advantage take place at Headquarters.

Dr. Schlesinger.

The Council have also to announce that they have agreed with Dr. Schlesinger to terminate the arrangement which retained him as a Consultant to the Research Department and he will thus be free to undertake private work.

Contributions to the Research Department.

The total contributions received towards the Research Department appeal now amounts to £1,776 16s. 6d. Of this £1,523 18s. 6d. has been previously acknowledged. The Council have therefore to gratefully acknowledge the following additional contributions received up to the end of October.

	£	s.	d.
R. Cooper & Sons (Sheffield) Ltd.	5	5	0
Moore & Wright (Sheffield) Ltd.	25	0	0
A. T. Green & Sons, Ltd.	1	1	0
The Brush Electrical Engineering Co. Ltd.	14	10	0
Ferranti, Ltd.	100	0	0
P. J. Westcott	2	2	0
Buck & Hickman, Ltd.	105	0	0
	£252	18	0

New Sub-Sections.

Shrewsbury. The preliminary meeting of this newly formed Sub-Section was held on 30th September at the Technical College. Mr. E. W. Hancock, M.B.E., the President of the parent Section addressed the audience on "The Aims of the Institution." The meeting which was presided over by the Mayor of Shrewsbury, Captain H. Steward, M.C., J.P., was attended by approximately one hundred members and visitors.

Derby. The inaugural meeting of this Sub-Section of Nottingham will take place on Monday, 20th November, at Derby. Sir Robert McLean, President Elect of the Institution, will intal Mr. H. J. Swift, of Rolls Royce as the first Chairman of this

newly formed Sub-Section. Sir Robert McLean will be supported by Mr. Hyde-Trutch, the Section President, and other officers of the Institution.

New Graduate Sections.

The Council have been pleased to sanction the formation of two new Graduate Sections, which will be attached to the Manchester and North Eastern Sections.

The Manchester Graduates will hold their first meeting on Wednesday, 15th November, when Miss Shaw, M.I.P.E., will lecture on Motion Study.

The Secretary of this new Graduate Section is Mr. H. J. Greatorix.

The North Eastern Graduates have an interesting programme for the coming session which commences on 7th November, with a film and a discussion.

Coventry Section.

Members, particularly those associated with the Coventry Section will regret to know that Mr. Buckland has found it necessary to resign his position as Hon. Secretary to that Section. Mr. Buckland, who has undertaken these duties for a period of several years has reluctantly relinquished the office due to pressure of business. He is succeeded by Mr. R. R. Brittain, the former Graduate Section Secretary, and Mr. E. B. Wall, has accepted the office of Secretary to the Graduates.

Southern Section.

Mr. C. S. Watson has been appointed Honorary Secretary to the Southern Section. His address is: Red House, Old Row, Cowes, Isle of Wight.

Personal.

Sir Charles Craven, Hon.M.I.P.E., has been elected President of the British Employers' Confederation. Sir Charles, Chairman of Vickers, Ltd., is also Industrial Adviser to the Minister of Production.

Mr. H. C. Town, M.I.P.E., has recently been appointed Principal of the Keighley Technical College.

Obituary.

We deeply regret to record the death of Mr. H. W. Healy, M.I.P.E., and Lieut. L. Wilson.

Mr. Healy was formerly General Manager of the Gramophone Company, Middlesex, but in 1936 joined the Parnall Aircraft Co., Ltd., and subsequently became managing director.

We have been informed by Mrs. Wilson, the mother of Lieut. Wilson, that her son lost his life at sea through enemy action.

Past Journals of the Institution.

In the September *Journal* a request was made to members to forward specific copies of their past Journals to head office in order to complete the Institution's records. The response to this request has been most gratifying, and we are indebted to many members who so readily responded. It is pleasing to state that there is now a complete set of Journals available at head office for reference purposes dating from January, 1934.

Membership Subscriptions.

Members who have not yet paid their annual subscription are reminded that the current financial year commenced on the 1st July, and the payment of these outstanding subscriptions would eliminate the necessity of sending out reminders. The co-operation of members in this matter would be appreciated.

Membership Numbers.

It has been our practice during the past two years when registering new members to allocate membership numbers to them, and this number always appears on the correspondence with the members concerned. In order to assist the administrative work it would be appreciated if all members would quote their number when communicating with head office.

INVESTMENTS 30th JUNE, 1944

SCHEDULE OF FUND INVESTMENTS.

	£ s. d.	£ s. d.
THE VISCOUNT NUFFIELD GIFT:		
£7124 19 10 3½% War Stock	7428 19 8	
8389 9 6 3% National Defence Stock 1954-58	8000 0 0	
9038 0 0 4% Canadian Pacific Railway Perpetual Consolidated Debenture Stock	9000 0 0	
		24428 19 8
THE LORD AUSTIN PRIZE FUND:		
£95 8 5 3½% War Stock		100 0 0
HUTCHINSON MEMORIAL FUND:		
£37 17 3 3½% War Stock		40 0 0
BUILDING AND DEVELOPMENT FUND:		
Loan to Treasury (free of interest)	1050 0 0	
£1000 0 0 3% Defence Bonds	1000 0 0	
£123 13 10 3½% War Stock	130 0 0	
Post Office Savings Bank	28 15 0	
		2208 15 0
Total as per Balance Sheet		£26777 14 8

SCHEDULE OF GENERAL INVESTMENTS (UNALLOCATED):

	£ s. d.
£692 13 5 2½% National War Bonds 1946-48	700 0 0
644 15 2 Ayr County Council 3% Redeemable Stock 1956	650 0 0
615 9 5 London County Consolidated 3% Stock 1956-61	620 0 0
595 18 2 Plymouth Corporation 3% Redeemable Stock 1956	600 0 0
148 3 11 3% War Stock 1955 59	150 0 0
382 13 8 3½% War Stock	400 0 0
190 16 11 3½% War Stock	200 0 0
95 8 5 3½% War Stock	100 0 0
Total as per Balance Sheet	£3420 0 0

SCHEDULE OF SINKING FUND POLICIES.

	£ s. d.
LEASEHOLD PREMISES SINKING FUND:	
Norwich Union Life Insurance Society Policy—Premiums Paid	763 0 0
DILAPIDATIONS RESERVE FUND:	
General Accident, Fire and Life Assurance Corporation Ltd., Policy—Premiums Paid	300 0 0
Total as per Balance Sheet	£1063 0 0

THE INSTITUTION OF PRODUCTION ENGINEERS

Balance Sheet as at 30th June, 1944

Liabilities.			£ s. d.
Sundry Creditors			1159 0 8
Subscriptions Received in Advance			183 1 8
The Viscount Nuffield Gift	£25000 0 0		
Less Loss on conversion of investment	571 0 4		
		24428 19 8	
The Lord Austin Prize Fund		100 0 0	
Hutchinson Memorial Fund		40 0	
Building and Development Fund		2208 15 0	
			26777 14 8
Leasehold Premises Sinking Fund		763 0 0	
Dilapidations Reserve Fund		300 0 0	
			1063 0 0
Income and Expenditure Account:			
Balance at 1st July, 1943		8996 17 6	

Assets.			£ s. d.
Leasehold Premises at cost			3481 0 0
(Depreciation is provided by a Sinking Fund)			
Furniture, Fittings and Plant at cost, *less* amount written off:			
Balance at 1st July, 1943	650 9 9		
Additions during the year	125 18 3		
	776 8 0		
Less amount written off	98 8 0		
			678 0 0
Fund Investments at cost: As Scheduled (Market value £27472)			26777 14 8
General Investments at cost: As Scheduled. (Market value £3409)			3420 0 0
Sinking Fund Policies: As Scheduled			1063 0 0
Sundry Debtors and Deposits			1310 5 7
Subscriptions in Arrear, not valued			—
Cash:			
At Bank	775 15 4		
At Post Office Savings Bank	41 16 6		

Balance at 1st July, 1943.....		8996 17 6	At Post Office Savings Bank		41 16 6

Less Excess of Expenditure over income for the year....	450 10 7		In Hand.....	6 5 7	
		8546 6 11			823 17 5
RESEARCH DEPARTMENT :			AMOUNT DUE FROM RESEARCH DEPARTMENT per contra		175 6 3
Sundry Creditors.....		229 17 6	RESEARCH DEPARTMENT :		
Amount due to Head Office per contra		175 6 3	Laboratory Plant and Furniture at cost, *less* amounts written off.....		1575 17 9
Balance of Income and Expenditure Account		1266 4 9	Stock of Publications *not valued*.....		—
			Sundry Debtors and Payments in Advance...		26 12 11
			Cash at Bank and in Hand.....		68 17 10
		£39400 12 5			£39400 12 5

NOTE.—(1) Certain investments are charged to the Bank as security for overdraft facilities.

(2) Owing to the war, adjustments will be required at a future date in respect of certain of the assets included in the above account.

AUDITORS' REPORT.—We have audited the above Balance Sheet dated 30th June, 1944, and we have obtained all the information and explanations we have required. The Australian Section accounts are not included in the above Balance Sheet. Subject to the foregoing, in our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Institution's affairs according to the best of our information and the explanations given us, and as shown by the books of the Institution.

Aldwych House, London, W.C.2.
2nd October, 1944.

(*Signed*) GIBSON, APPLLBY, & Co., Auditors,
Chartered Accountants.

ERNEST J. H. LEMON
President

H. A. HARTLEY
Chairman of Council and Finance Com.

K. G. FENELON
General Secretary and Treasurer.

THE INSTITUTION OF PRODUCTION ENGINEERS

Income and Expenditure Account for the Year Ended 30th June, 1944

Dr.	£	s.	d.		£	s.	d.	Cr.
To Salaries	4654	9	1	By Subscriptions received :				
„ Rent, Lighting, Heating and Cleaning	711	5	2	Current 7407 18 2				
„ Local Section Expenses	560	12	11	Arrears 301 5 0				
„ Printing, Postages, Stationery and Telephone	1061	17	3		7709	3	2	
„ Cost of Journal and Bulletin	3564	15	7	„ Interest on Investments	1078	1	4	
„ Travelling and Expenses of Meetings other than Section Meetings	460	9	11	„ Journal Receipts	4096	5	5	
„ Professional Charges and Insurances	190	15	0	„ Contributions received for Research 3025 6 6				
„ Donations and Grants	111	5	0	„ Other Research Receipts 818 0 5				
„ Repairs and Renewals	317	11	9		3843	6	11	
„ Annual Luncheon	65	0	5	„ Transfer from Research Account for Management Expenses	500	0	0	

„ Miscellaneous	102	19	8
„ Transfer to Leasehold Premises Sinking Fund	127	3	4
„ Transfer to Dilapidations Reserve Fund	100	0	0
„ Transfer to Building and Development Fund	52	10	0
„ Amount written off Furniture, Fittings and Plant	98	8	0
„ Amount transferred to Research Department Account	5498	4	4
	£17677	7	5

„ Balance, being Excess of Expenditure over Income	450	10	7
	£17677	7	5

THE INSTITUTION OF PRODUCTION ENGINEERS

RESEARCH DEPARTMENT

BALANCE SHEET AS AT 30TH JUNE, 1944

LIABILITIES.			£	s.	d.	ASSETS.			£	s.	d.
SUNDRY CREDITORS			229	17	6	PLANT AND EQUIPMENT at cost *less* amount written off:					
HEAD OFFICE			175	6	3	Balance at 1st July, 1943	1337	18 8			
INCOME AND EXPENDITURE ACCOUNT:						Additions during year	592	16 3			
Balance at 1st July, 1943	2848	15 6					1930	14 11			
Less Excess of Expenditure over Income for the year	1582	10 9				*Less* Depreciation	365	14 8			
			1266	4	9				1565	0	3
						OFFICE FURNITURE at cost, *less* amount written off:					
						Balance at 1st July, 1943	14	10 0			
						Additions during year		—			
							14	10 0			
						Less Depreciation	3	12 6			
									10	17	6

					10 17 6

STOCK OF PUBLICATIONS *not valued*					—
SUNDRY DEBTORS AND PAYMENTS IN ADVANCE					26 12 11
CASH :					
Deposit Account : Post Office		19	19	4	
Petty Cash : Bank		94	10	1	
Petty Cash : In Hand ...		1	13	1	
		116	2	6	
Less Bank Account overdrawn		47	4	8	
					68 17 10
	£1671	8	6		£1671 8 6

AUDITORS' REPORT.—We have audited the above Balance Sheet of the Institution of Production Engineers' Research Department dated the 30th June, 1944, and we have obtained all the information and explanations we have required. In our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Department's affairs according to the best of our information and the explanations given us and as shown by the Books of the Department.

Aldwych House, London, W.C.2.
2nd October, 1944.

(*Signed*) GIBSON, APPLEBY & CO., AUDITORS,
Chartered Accountants.

ERNEST J. H. LEMON
President

K. G. FENELON
General Secretary and Treasurer of the Institution

THE INSTITUTION OF PRODUCTION ENGINEERS

RESEARCH DEPARTMENT

Dr. INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 30TH JUNE, 1944 Cr.

	£	s.	d.		£	s.	d.
To Salaries and Wages	5198	8	2	By Grant from Institution Funds	1654	17	5
,, Management Expenses	500	0	0	,, Transfer from the Institution of amounts received for Research:			
,, Rent, Lighting, Heating and Cleaning	54	16	9	Contributions 3025 6 6			
,, Printing, Postages, Stationery and Telephone	128	19	0	Bank and Post Office Interest 13 18 6			
,, Travelling and Expenses of Meetings	146	10	9	Research Receipts..... 559 0 8			
,, Professional Charges and Insurances	85	2	9	Sale of Technical Publications 184 4 9			
,, Laboratory Materials	511	4	5	Royalty on Publications 60 16 6			
,, Repairs and Renewals to Plant and Equipment	5	0	6		3843	6	11
,, Miscellaneous	79	5	7	,, Balance, being Excess of Expenditure over Income	1582	10	9
,, Income Tax on Deposit Interest ...	2	0	0				
,, Depreciation:							
Plant and Equipment 365 14 8							
Office Furniture 3 12 6							
	369	7	2				
	£7080	15	1		£7080	15	1

DESIGN CONSIDERATIONS FOR DIECASTING

Paper presented to the Institution, Wolverhampton Section, on the 17th March, 1944, by H. W. Fairbairn

Introduction.

The die casting process concerns essentially the production of castings from a permanent mould and is one that most engineers have almost certainly had experience with in some form or another.

That the mould is permanent explains the fundamental difference to the once traditional method of producing castings from sand moulds that are destroyed after the production of each casting.

The advent of the die casting process was of tremendous importance to the production engineer, for with it came assurance of adequate supplies of castings to feed his productive machinery. He was assured too, of uniformity of castings, machining was minimised and oft-times eliminated. Thinner and lighter castings with a superior surface finish became possible. All of these factors contributed to lower costs, the greatest saving, however, is usually in the prime cost of the casting as compared with a similar product of the sand foundry.

Components are often made by the process in aluminium or zinc, not because of any design advantage in these materials, but because they can be produced more economically this way than in any other material or by any other process.

Designers and production engineers in nearly all branches of industry have made considerable use of die castings, and die castings have contributed very materially on the industrial "War Front."

In spite of these facts however, there is urgent need for greater co-operation between the designer, production engineer and the foundry engineer. The result of such joint action will be manifest in a number of ways beneficial to all parties. Among them will be reduction of costs and man-hours of machining, improved strength/weight ratios, compactness and improved shape, line and appearance of the project.

There is evidence of such co-operation in some of the products of other countries, which are often superior to ours in these matters, even if their functional performance is not always improved. This is said in the full knowledge that it is provocative but in the hope that it will, in conjunction with the subject matter of the paper stimulate a design and production interest in the application of die-

castings. If this interest can be aroused it is certain that much better die cast products will ensue reflecting credit to all parties concerned.

Gravity Castings.

Until recent years the best known form of die casting was what we term the " gravity casting " and the Americans the " permanent

Fig. 1.—Pouring a gravity casting. Note tilted die to facilitate smooth entry of metal

mould casting." These are produced usually in aluminium and magnesium base alloys. Brass and other yellow metals to a much smaller extent are also produced this way. Zinc base alloys, while they can be most readily gravity die cast, are generally considered unsatisfactory. This is attributable to inherent coarse grain structure when cast this way, with resultant embrittlement and unreliability in service when subjected to undue vibration, etc.

The molten metal to be cast into the die is usually supplied from

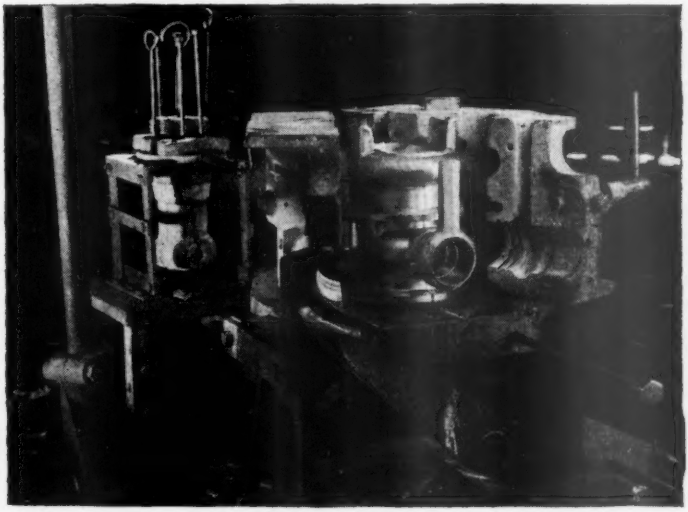


Fig. 2.—Gravity casting ready for removal from die. Note, reassembled collapsible top core. Lever in foreground operates bottom core through a rack and pinion mechanism.

a manually operated ladle. The height of die provided above the impression cavity creating the sole filling pressure.

The heaviest aluminium gravity casting now in production weighs, I believe, approximately 120 lb., while at the other end of the scale there are those weighing only fractions of an ounce.

The collapsible metal core to facilitate the production of castings to include undercut coring has been a valuable asset to founder and consumer alike, and has made possible for instance, the aluminium die-cast automobile piston, see Fig. 3. Sand cores may, if necessary, be used in conjunction with a gravity die where a collapsible metal core is not practicable, e.g., to form the water chamber of an auto-

mobile cylinder head, see Fig. 4. Such examples of coring, whilst being practicable and economically sound for the applications mentioned, should as a general rule, be avoided wherever possible, for the tool and operative costs are comparatively high. This is especially true in the case of the sand core.

The rapid chilling of the cast material effected by the metallic nature of the mould results in a small grain structure. Because of this and the fact that a good gravity casting is virtually free of even microporosity, it can, as a general rule, be accepted that

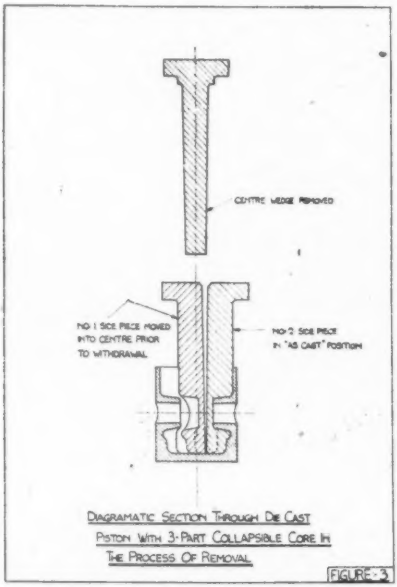

CENTRE WEDGE REMOVED
NO 1 SIDE PIECE MOVED INTO CENTRE PRIOR TO WITHDRAWAL
NO 2 SIDE PIECE IN "AS CAST" POSITION
DIAGRAMATIC SECTION THROUGH DIE CAST PISTON WITH 3-PART COLLAPSIBLE CORE IN THE PROCESS OF REMOVAL
FIGURE 3

Fig. 3.—Diagram of piston with collapsible metal core.

aluminium and magnesium alloys in this form are stronger than when produced by any other casting process.

The Pressure Die-Casting Process.

Concurrently with the development of the gravity casting process in this country, the pressure die casting process was being developed almost to the exclusion of the former in America. It was after the 1914-1918 war before any practical interest was taken in the process

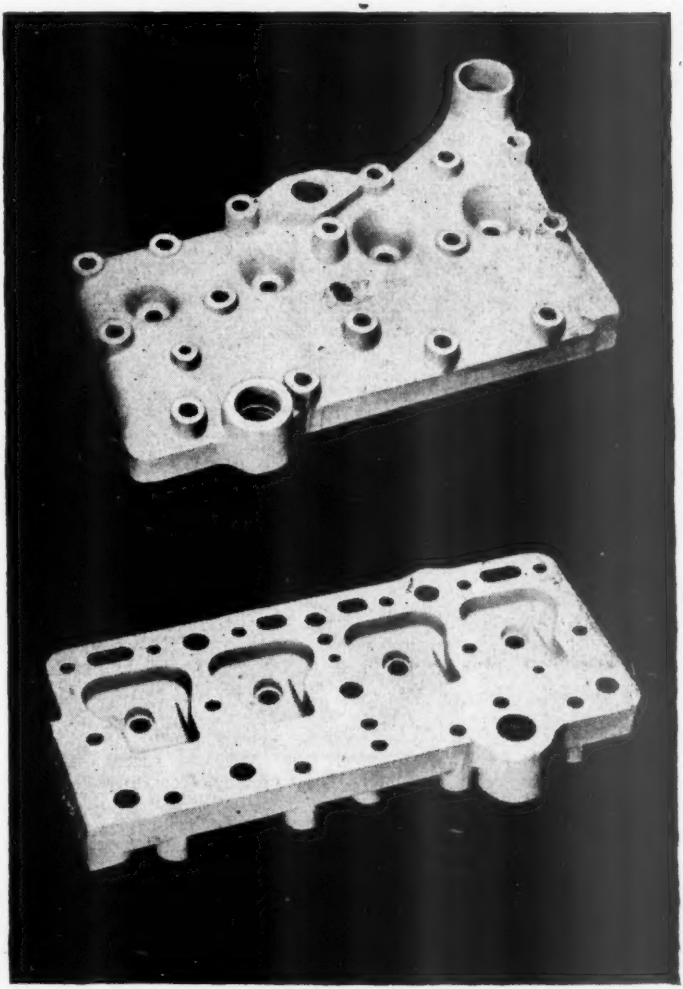


Fig. 4.—Two views of gravity die-cast automobile cylinder head. Sand core is used for coring water jacket. Bolt holes, etc., are die-cast.

in England. The pressure die cast aluminium components of the Hoover vacuum cleaner, however, provided an early example of the immense possibilities of its future.

The pressure die casting process, as its name implies, involves the use of pressure for the purpose of filling the mould with molten metal. The method of application and intensity varies according to

Fig. 5.—Modern zinc base pressure casting machine (Reed Prentice) of the "Hot Chamber" type.

Note (a) Hydraulically operated toggle die press.
(b) Injection operating cylinder behind operator.

the system used, ranging in fact from a few hundred lbs. per sq. in. up to 20,000 lbs. per sq. in. in some extreme cases.

In the quest for lower costs, economy of man power and conservation of materials the following factors outline the advantages of the pressure over the gravity casting process.

(a) Improved surface finish.

(b) Improved dimensional accuracy.

(c) The ability to produce thinner wall sections.

(d) Considerably improved rates of production.

The latter factor is possible because of the accelerated rates of solidification affected with water cooled dies. The dies are also

invariably operated within hydraulic or pneumatic presses. Cores and ejection of castings are mechanically and usually automatically operated.

Tin, lead, zinc, aluminium and magnesium base alloys may all be pressure die cast. Also certain of the yellow metals.

The number of tin and lead castings produced is relatively small,

Fig. 6.—"Cold Chamber" type pressure-casting machine.

Note.—(a) Operator ladling metal into injection cylinder.
(b) Separate melting or holding furnace in bottom right-hand corner.

although many Veeder counter wheels and certain surgical appliances are made in tin, and accumulator plates in lead. They are both very easily cast materials, largely because of their low melting temperatures, but have poor mechanical properties.

Enormous quantities of zinc base pressure castings are produced in this country. This was also the case in America prior to the war, now however for aircraft and armaments, aluminium and magnesium pressure castings are in greater demand. Zinc base pressure castings under normal atmospheric conditions and temperatures possess relatively high mechanical properties. These however, in common with castings in any material, will deteriorate if porosity is present.

Fig. 6a.—"Close up" of one half of die for binocular body on Cold Chamber pressure-casting machine.

Note.—(a) Cores in withdrawn position.
(b) Casting complete with runner.

The material can be readily cast at relatively low temperatures and pressures, with production rates varying from 60 to 600 shots per hour according to size of casting. Multi-impression dies where size and complexity of casting permit, furnish multiples of these figures in terms of castings per hour.

These considerations, it may be added, have tempted many manufacturing concerns to install and operate machines to produce zinc base pressure castings in their own factories. In a number of unfortunate instances they have had no previous metallurgical experience of alloying or melting of metals, die design, or casting

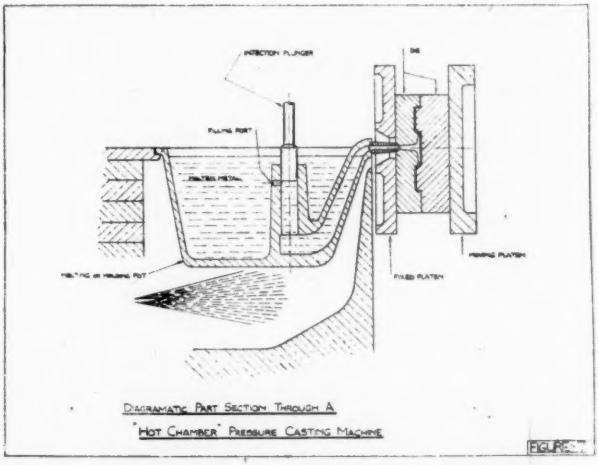


Fig. 7.—Diagram of Hot Chamber pressure casting machine.

technique; the two latter considerations involve a multitude of other factors, such as benting, metal velocities, control of metal and die temperatures, etc. In spite of this they may succeed in producing a seemingly excellent casting but often riddled with porosity and a metallurgical structure that revives memories of failures with this material in the past. Disintegration and intergranular corrosion are prominent among the unpleasant memories; to this day in the domestic electric meter industry strong prejudice against the material still prevails through failures of this nature with castings incorrectly produced in the early days of the process. Such troubles happily are avoidable if a high purity base material is used in conjunction with correct and rigid foundry procedure. It is when these considerations have not been met or the material

wrongly specified that has resulted in failures and loss of confidence in the material and process.

The pressure casting has often, and rightly, been criticised in the past on the score of porosity. Time has changed this, and to-day vast numbers of virtually non-porous castings are satisfactorily subjected to X-ray examination and others to working pressures of 1,000 lb. per sq. in. Pressure die casting processes, while all involve the use of comparatively high casting pressures, vary in methods of application. As these methods are largely responsible for the degree

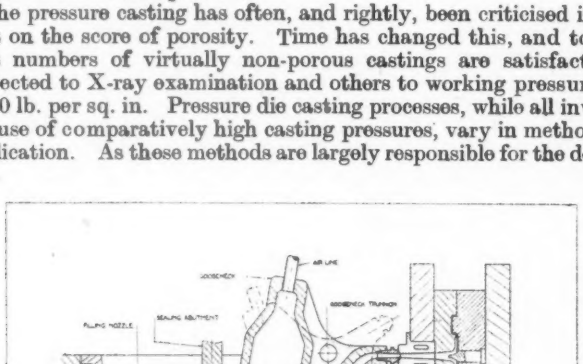


Fig. 8.—Diagram of Gooseneck pressure casting machine.

of porosity in their products some reference to them is necessary. They are :—

(*a*) *Hot chamber machines.* (See Fig. 7). Situated within the melting or holding pot in such machines is an injection cylinder with port arrangements to facilitate entry of metal, from whence it is displaced by a plunger into the die. The plunger may be operated either manually through a lever system, pneumatically or hydraulically. Providing the die be adequately vented and the metal velocity sensitively regulated, serious air inclusions may be avoided. The desired control of velocity can be obtained only by the employment of hydraulic power for the operation of the injection piston, other means of operation have been proved inadequate in this respect. Even with a suitably regulated injection piston other

factors such as metal and die temperature, adequate venting and correct positioning of runners, need to be in phase to obtain sound castings.

The system is in general use of zinc base and other low melting point metals but never for aluminium.

(*b*) *Goose-neck machines.* (See Fig. 8). So called because of the shape of the metal container from which the metal is transferred to the die by direct air pressure. Pressures are never in excess of 700 lb. per sq. in. The system is used principally for the aluminium alloys, and sometimes for zinc base.

Castings produced by this system have the tantalizing habit of possessing a really beautiful and tough skin, but lying hidden and awaiting to be revealed upon machining or pressure test is an "aerated structure." This is due very largely to the almost complete lack of velocity control of the metal entering the mould. The pressure foundry phraseology in the use of the term "shot" to describe the filling of the mould, effectively symbolises the speed of this operation with this type of machine.

The fact that molten aluminium alloys, particularly those with high silicon contents such as L.33, can rapidly dissolve iron is a further objection to the system. The gooseneck must necessarily be of a ferrous material to withstand the pressures, and is rapidly absorbed, with the result that the castings have an iron content which impairs their mechanical properties.

(*c*) *The cold chamber process.* (See Fig. 9). Used mainly for aluminium. The metal in this case is ladled for each casting from a furnace, separate and quite independent of the machine, into a cylinder attached via the press platen to the die. Enormous hydraulic pressures ranging between 3,000—20,000 lb. per sq. in. transfer it by means of a plunger into the die. The significance of this is that:

(1) Velocity control of the injection piston through the hydraulic system can be regulated to avoid air inclusions, and,

(2) Porosity caused by the shrinkage of the cooling metal may in some cases be cured. The molten metal to fill the voids created between the crystal formations of the solidifying casting, exist only at the runner, and the tremendous pressures that can be imparted are used to convey this still molten metal through the intervening metal of the rapidly solidifying casting to the voids.

The fact that the melting is remote from the injection cylinder and piston means that contamination from iron "pick up" does not occur as the molten material is only momentarily in contact with

the pressure unit. With alloys such as L.33, graphitic melting crucibles are used instead of the customary cast iron pot.

Whilst primarily for aluminium, the system is used to some extent for magnesium, although great care has to be exercised to prevent oxide and flux inclusions occurring during the ladling.

The yellow metals can also be cast this way, although short die life occasioned through high melting temperatures and casting pressures has resulted in a more limited application.

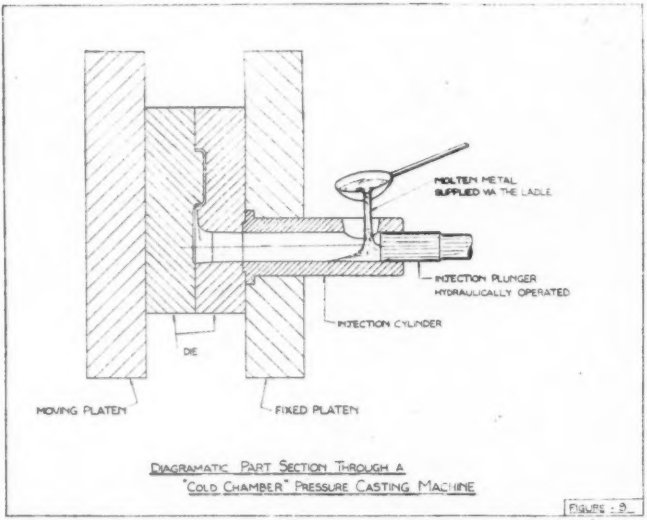


Fig. 9.—Diagram of Cold Chamber pressure casting machine.

Zinc may be cast this way but the relatively high operative cost is the main objection.

The production rates vary in accordance with their complexity, but a simple casting involving a plain two parted die may be produced at the rate of 200 per hour per impression. With the average run of work however, 50 to 120 " shots " per hour is more customary.

It will be apparent from the foregoing that pressure castings can be sound and solid when made by the right system and with suitable foundry practice. Wall thickness should however, be kept to a minimum and local heavy sections or bosses studiously avoided unless they can be fed direct from the runner. Given these con-

ditions and within the scope and size of pressure castings which are relatively small compared with those possible by the gravity process, the former type of product may even occasionally possess slightly superior mechanical properties than the latter. The range of alloys that can be satisfactorily produced in the pressure foundry unfortunately is more limited, fully-heat treated pressure castings are not yet possible. More on these points however, will be said later.

Dimensional Accuracy of Die Castings, With Special References To Cast Threads and Gears.

The accuracy and uniformity of die castings has probably done more to popularize them in industry than any other factor and the economies effected by this characteristic are considerable.

That the general accuracy is excellent will be apparent from the information set out on Table No. 2. Pressure castings made under favourable conditions can in their " as cast " state be as accurate as some machined products.

The degree of accuracy is dependent upon a number of considerations usually inter-connected and prominent among these are :—

(a) Alloy and process employed.

(b) The location of die joints and cores.

(c) Position of the runner and/or risers.

(d) " Machineability " of the mould.

Imperfect die and core closures caused probably by the adhesions of " flash " or foreign matter on the joints or core locations will result in slightly oversized castings and ovality in the case of the cylindrical type of casting when the latter is made from an axially jointed die. Locking mechanisms for slideable cores may wear or the core itself may bend if of a slender form and occasion further dimensional variations. The casting may distort upon cooling because of its shape or through insufficient taper causing it to be strained during the process of ejection from the die.

All of these considerations excepting the effects of distortion have been taken into account and allowed for in the tolerances given in Table No. 2. These are representative of the tolerances to be expected in production and not solely for the initial samples from the tools.

It is strongly urged that dimensional accuracy be discussed with the founders not only before the tolerances are specified but before the design is finalised. If this advice is followed the design can often be modified to facilitate the " as cast " accuracy by enabling the casting to be run or jointed another way. In any case the " as cast " accuracy can usually be reliably assessed in the design stage and it then becomes a plain issue of whether subsequently to

Table 2.—Dimensional Data for Die-castings.

TABLE NUMBER 2.

Eccentricity Tolerance Between X & X' = 0.001" If Core 'F' Is Located At Both Ends
Eccentricity Tolerance Between X & X' To X² = 0.004" If Core 'F' Is Located At Both Ends & To Core 'E'.
Note! These Tolerances Apply Only When Diameters Exceed ½" And Are Not More Than 1½ Diameters Long.

± 0.002" Up To 1½" Centres, Add ± 0.001" For Each Additional Inch. Note! This Is Relative To Core 'E' Only & Not Core 'F'.

Note! Core 'C' Is Attached To Block 'B' And Core 'D' Is Attached To Block 'A'.

Diagram Illustrating Eccentricity Referred To In Notes On Tolerances

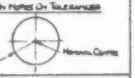
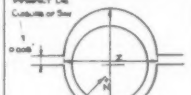
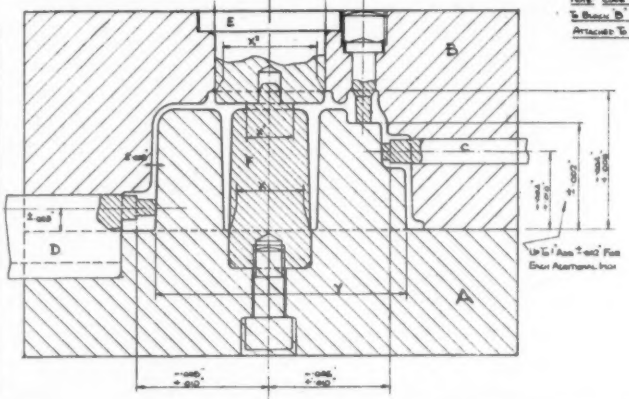


Diagram To Show Typical Effect of Improper Closing Of An Axially Joint, As Due For A Cylindrical Component



"Z to 0.005" Z May However Be Made In The 0.004 Below Nominal If So This Would Read Z ± .001"



Tolerances on Diameters } 0.005" Up To ¾" Dia, Add ± 0.002" For Each Additional Inch of Diameter (Aluminium & Electron)
X, X' & X² & Dimension 'Y' } 0.001" Up To ¾" Dia, Add ± 0.001" For Each Additional Inch of Diameter (Zinc)

The Tolerances Indicated On Diagrams Refer To Pressure Die Castings Only
Tolerances For Gravity Castings Are Approximately Double Those Indicated.

Tolerances and General Information are for Guidance Only and Cannot be Guaranteed Correct in All Instances. It May Be That Under Specially Favourable Conditions, Tolerances Can Be Reduced.

	Pressure	Gravity	General Notes
Minimum Size of Cored Holes	⅛" Dia x ⅝" Long (In Zinc) ⅛" Dia x ⅜" Long (In Aluminium & Electron)	¼" Dia x ½" Long	Centre Pins Can Be Inserted Often To Be Cored In Place of Holes Too Small or Otherwise Difficult To Core.
Taper In Cored Holes of Zinc Castings	½" Included Up To ½" Dia In Special Cases ¼" Included Up To 1" Dia Taper Can Practically 1" Included Above 1" Dia Be Dispensed With		Maximum Possible Taper Should Always Be Allowed In Cored Holes
Taper In Cored Holes of Aluminium & Electron Castings	1" Included Up To ½" Dia Three Are Minimum & ½" Included Up To 1" Dia Should Be Exceeded 2" Included Above 1" Dia Wherever Possible	2" Included Minimum Taper On All Holes	Long Cores For Producing Blind Holes And Therefore Unable To Be Pulled Should Be Avoided Especially For Aluminium & Electron For Guidance - For Alum & Electron, A Length of 2 Dias or ⅜" Dia & Up To 4 Dias In Usually Considered Maximum, And A Length of 3 Dias or 2 Dia Or Over Is Usually Considered Maximum For Zinc, These Lengths Can Be Doubled. Anything Contemplated In Excess of These Figures Should Be Discussed With The Maker.
Maximum Size of Casting Alum & Electron & Zinc	250 lbs Projected Area 15" Dia	On Special Presses Machines Three Sizes & Weights In Certain Instances May Be	
Maximum Weight of Casting Aluminium	10 Lbs		

machine or not. This may well prevent the avoidance of disappointment and exasperation at a later date.

In a general way it can be assumed that tin base alloys can be pressure die cast with the greatest degree of accuracy, but generally they have very little bulk, seldom weighing more than fractions of an ounce.

Zinc base alloys, pressure die cast, are the next best, and where they are not affected by die joint or moving cores certain dimensions can be held to within—.003 in. Very little taper in core holes is needed for these alloys and machining may often be entirely eliminated.

The aluminium and magnesium alloys closely approach the zinc alloys on the score of accuracy when pressure die cast, but greater allowances for taper are necessary in cored holes.

Tolerances for gravity die casting are about double those needed for pressure castings.

Cast Threads.

The pressure die cast thread has been a feature of war time production methods. There are to-day some hundreds of pressure die casting machines in this country, turning out vast quantities of small threaded components. These are invariably in zinc base, in which internal as well as external threads are being satisfactorily produced.

Produced under favourable conditions and from a solid die or ring, whereby the casting is either screwed out of the die, or the ring screwed off the casting, external threads to B.E.S.A. medium tolerances are possible without subsequent finishing operations. If it is necessary to use a split die or ring, flash will ultimately accrue between the threads at the joint line and a finishing operation becomes necessary.

The internal threads in zinc castings, whilst being comparatively accurate, are not quite up to the same standard as the external threads.

Whilst external threads are satisfactorily cast in aluminium and magnesium pressure castings to practically the same tolerances as in zinc, internal threads cannot be satisfactorily produced.

The pitch of cast threads should always be as coarse as possible, by while 26 T.P.I. are possible in zinc, 16 T.P.I. is considered the practical limit for aluminium and magnesium.

Cast Gears.

Pressure die cast gears and chain wheels are possible in all of the die casting alloys, but are generally to be found in the zinc base alloys. The greater degree of accuracy possible, and the comparatively hard cast surface with its good wearing properties are the chief reasons for this choice.

Plain spur and bevel gears are reasonably easy to die cast, but spiral and worm gears present difficulties of such a nature that the process is considered inadequate for their production.

The illustrated gear box assembly (See Fig. 10), used on the wringing machine attachment of the well known domestic washing machine marketed by the Hotpoint Electric Appliance Co. Ltd. is a notable all-die-cast unit in zinc base alloy.

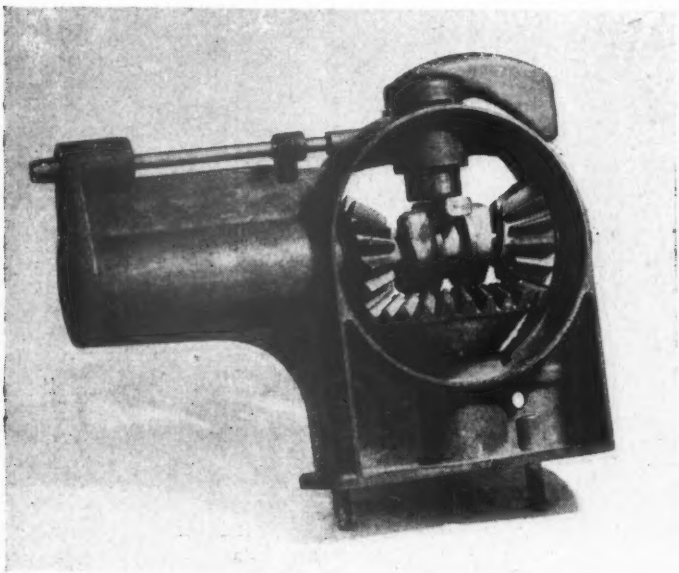


Fig. 10.—Pressure die cast gear box assembly in zinc base with covers removed (not shown). All gears are die-cast. Bushes and studs, etc., are "cast in" inserts
(By courtesy of Messrs. Hot Point Electric Appliance Co. Ltd.)

The crown wheel and bevel pinions are meshed together in their "as die cast" condition and have successfully supplanted high tensile steel gears. Prior to the use of this latter material an ordinary case hardened steel was employed. With this material trouble was experienced with chipping and flaking of the teeth. The pressure cast wheels, by way of contrast over years of service, have given no trouble whatever.

The gear box as a whole is a fine example of the result of co-operation between designer and foundry, and its remarkable

success in service has well repaid the careful thought expended during its development.

Die Casting Alloys.

In this section of the paper, referring to alloys, I am not proposing to read long lists of analyses and properties of the many and varied alloys. These are readily available in convenient and tabulated form. The object of my remarks will be to emphasize the important

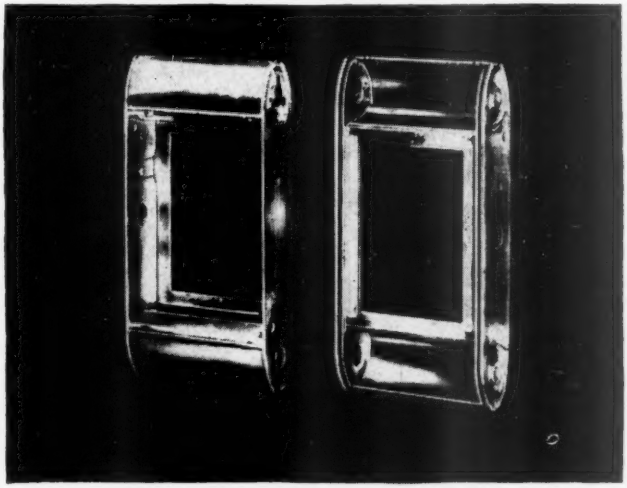


Fig. 11.—Pressure die cast camera case in "Elektron" magnesium.
(By courtesy of Messrs. Houghton Butcher Manufacturing Company Ltd.)

fact that the various materials and alloys have their own characteristics not only in the physical and mechanical sense, but also in their behaviour in the foundry. Each of these alloys have their own castability factor in respect of the particular casting that may be under discussion, this unfortunately cannot be tabulated, but nevertheless must be legislated for when specifying the material. Again this is only possible by consulting the foundry unless there is prior experience with a similar casting.

The base materials that can be die-dast have already received mention, but considerations such as strength/weight ratios, mechanical and physical properties at normal, elevated, and sub-normal temperatures, corrosive characteristics and suitability for

the various die casting processes demand an intimate knowledge of the many available alloys. It is only possible within the scope of this paper to give a very bare summary of some of these characteristics, but it is hoped that it will present some idea of the importance of discrimination in the choice of alloys .

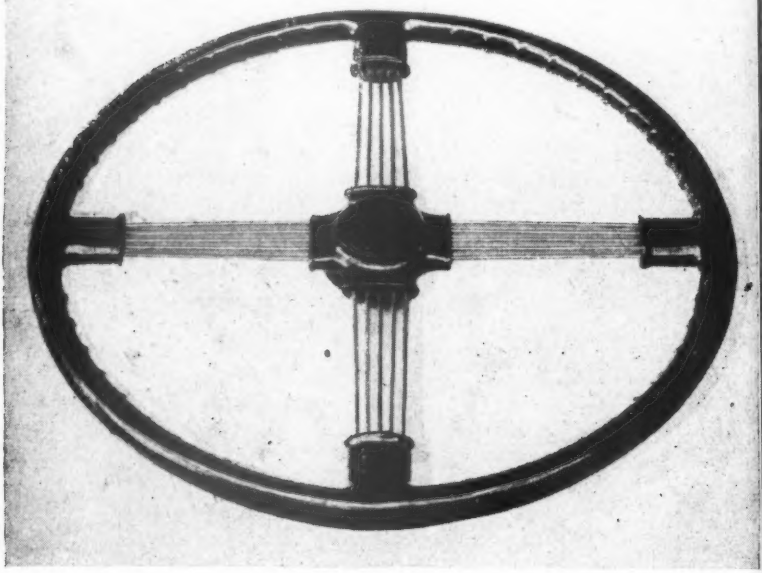


Fig. 12.—Automobile steering wheel. Spring spokes are bonded together by pressure die cast centre hub.

Zinc Base Alloys.

Zinc base in which many millions of pressure die castings per annum are made has a specific gravity of 6.7 It is much heavier than the aluminium and magnesium alloys with specific gravities of approximately 2.7 and 1.81 respectively.

Reference has already been made to the objectional characteristics of this material that was experienced in the early days of the process. Among them were abnormal growth and embrittlement even to the point of disintegration of the castings, occurring not only in service but in storage. The root of this trouble was

eventually traced to poor quality base materials contaminated by impurity elements. Modern refining methods have resulted in zinc of the very highest purity being available and, correctly alloyed with magnesium, aluminium and/or copper, with strict control of the impurities such as iron, lead, cadmium and tin, together with equally strict foundry control, good mechanical properties at normal temperatures and atmospheric conditions are obtainable with pressure die castings.

Mazak 5, a proprietary brand of zinc alloy with excellent casting characteristics, can, under the best of conditions give the following properties :—

	Original properties (immediately after casting)	*Properties after 3 years normal ageing*
Ultimate Tensile. tons/ sq. in.	19.87	17.35
Elongation % on 2 in. ...	3	4.3
*Impact Strength ft. lb. ...	17.5	18
Hardness Brinell No. ...	76	80

*=Specimen ½ in. sq. × 40 mm. long. Tested on Charpy machine of 40 ft. lb. capacity.
N.B.—The above figures are quoted from the "Mazak Manual."

Under normal conditions of service and at normal temperatures, Mazak 5 substantially retains these properties but suffers from slight dimensional changes which can however be arrested by an artificial ageing or stabilising treatment. The unfortunate consequence of the treatment is a deterioration of the mechanical properties, the most serious being the impact strength which falls to 5.25 ft. lb. This treatment is therefore never recommended for this alloy. Mazak 3, a copper free alloy which is more difficult to cast than Mazak 5, will however, retain the following properties after stabilizing :

Ultimate tensile ...	14.14 tons per sq. in.
Elongation	9.1% on 2 in.
Impact Strength ...	19.5 ft. lb.
Brinell No.	55

This alloy in its treated condition is accordingly advised for castings of intricate shapes that are required to retain an high order of accuracy over a long period of years.

At sub-normal temperatures the impact strength of both alloys is appreciably reduced and the resultant embrittlement precludes their use when subject to high shock loadings at these temperatures.

The mechanical properties at elevated temperatures are also poor when compared with aluminium primarily due to their low melting points.

Aluminium Alloys.

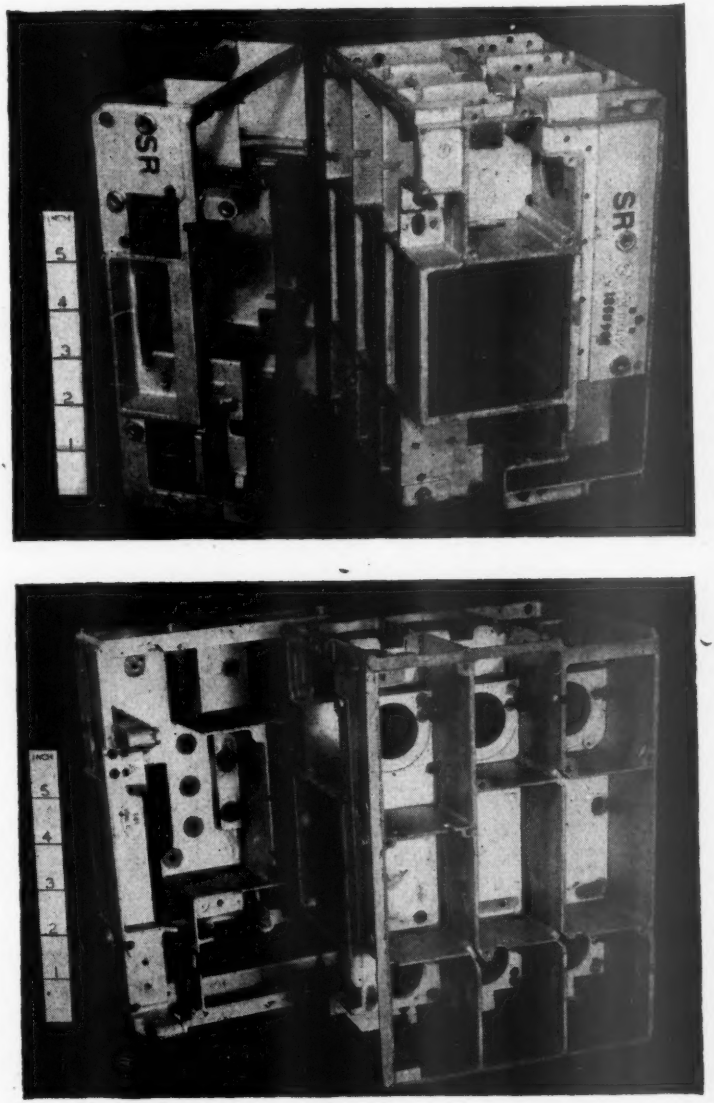
The principal alloying elements with aluminium are, copper zinc, magnesium, manganese, silicon, nickel and for special purposes like grain refining, small additions of titanium are made.

The mechanical and physical properties of a number of these alloys can be considerably improved by various forms of heat-treatment ageing and annealing processes.

Cast aluminium alloys in common with magnesium alloys are strongest when die cast. In this form however, there is among them a considerable diversity of properties. For instance " Y " (BSL.35) alloy is renowned for high strength and hardness at elevated temperatures, whereas another alloy such as Birmabright (DTD.165) although inferior in this respect possesses its own characteristics of greater elongation and high resistance to corrosion, even to sea-water attack. We find then, that while " Y " alloy is regularly specified for internal combustion engine pistons and cylinder heads, Birmabright has many marine and outdoor applications.

L.33 also possesses good corrosion resisting properties (which in common with other aluminium alloys can be improved by anodic treatment), in a foundry sense runs more freely than Birmabright and is therefore more suited for die castings involving large thin areas.

Among the aluminium alloys suitable for die castings are those that yield test bar figures as high as 26 U.T.S. and 4% elongation. From the foundry angle they are often difficult to handle, due largely to their sensitivity to contamination, tendency to shrinkage cracks and the necessity for ample feed at heavy sections. Unless the casting design is such that the two latter considerations can be adequately catered for, it is certain that the high test bar figures will not be achieved in the casting. In fact, greater average strength and the ability to withstand high working pressures is oft times obtained in a complex casting with an alloy of less potential strength. Test bar figures of any alloy in fact are only a very rough guide to the properties that may be expected in the casting, and should be treated as such.



Figs. 13A and B.—Two views of Radio Chassis. (German origin). Produced as pressure die-castings in magnesium alloy. Notable for complexity of form and are striking examples of what may be achieved by design co-operation between consumer and foundry. *(By courtesy of M.A.P.)*

The following list of aluminium base alloys are all regularly used in the gravity foundries :—

Specification	*Common Designation*
B.S.L.8	L.8
B.S.L.35	" Y " Alloy.
B.S.L.33	Alpax or L33
DTD.133B	RR.50
DTD.304	NA226/T92
DTD.165	" Birmabright."
DTD.424	D7 or D8
DTD.428	" Z."

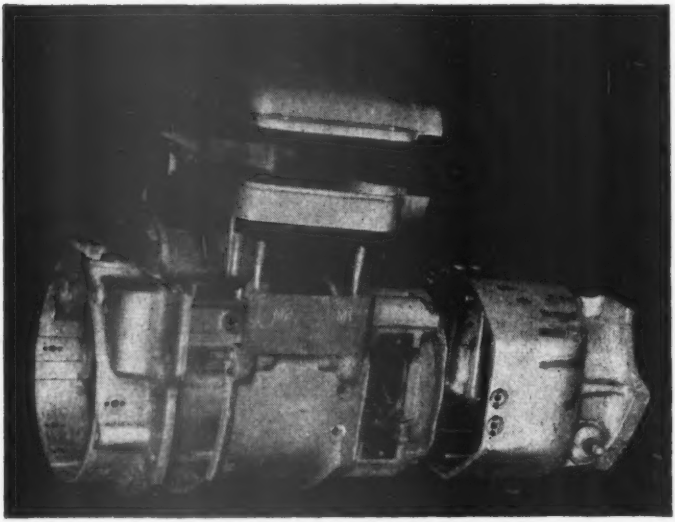


Fig. 14A.—" Exploded " view of die-castings in magneto assembly. (German origin).

In the pressure die casting foundries of this country castings are made usually in either L.33, DTD.424, Birmabright or RR.50.

Super high-strength aluminium alloys such as DTD.304 or B.S.L.35, need lengthy high temperature heat-treatments (solution treatment) followed by a low temperature (precipitation or accelerated ageing treatment) to obtain their properties.

The heat-treatment temperatures and periods for DTD.304 for example are :—545°C. for a minimum period of 12 hrs., followed by a 12—16 hr. period at 120—170°C. Gravity die castings in

these materials respond readily to this processing, in fact, their mechanical properties are invariably better than if sand cast.

Pressure castings, unfortunately, do not react in the same satisfactory way to the high temperature treatments. Alloys requiring this form of heat-treatment, among them being DTD.304 and B.S.L.35 are therefore ruled out for pressure die castings.

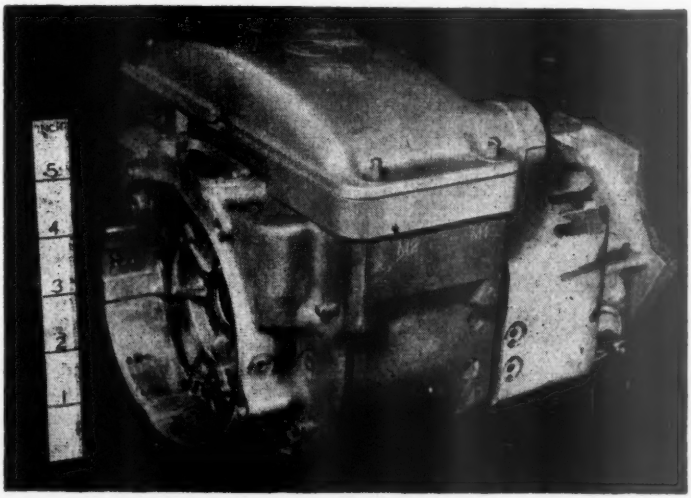


Fig. 14B.

Pressure castings can however, be successfully treated at the lower temperatures. Pressure castings in RR.50 for instance, when sound and produced by the cold chamber system, can be satisfactorily treated in accordance with the specification at 155°—170° C. for the short period of 8 hrs. RR.50 however is not in general use in the pressure casting foundries because such alloys as L.33 (11—13%Si) and DTD.424 (2—4% Cu and 3—6%Si) run much more freely and are not so susceptible to shrinkage cracking and are therefore more easily worked for the extremely thin castings that are so typical of the process.

These two alloys, which incidentally do not require heat-treating, are in general application for pressure die castings and have moderately high mechanical properties. The following properties are representative of what may be expected from castings produced by the cold chamber system. Included in the table are also the mechanical properties of DTD.165 when pressure cast.

Alloy	U.T.S. tons sq.in.	Elongation per cent	Impact Strength* Charpy	B.H. No.
L.33.	14.6	4.2	6.3 ft. lb.	68
DTD.424.	14.75	4	5.64 ft. lb.	80.5
DTD.165.	15.5	9.5	21.0 ft. lb.	

* Specimen $\frac{1}{2}$ in. sq. × 40 m.m.

Magnesium Alloys.

The foundry problems beset by this material are far greater than the others already described. Its insatiable appetite for oxygen and the rapidity with which it will burn when molten, demands as may well be imagined strict control of melting and pouring procedure.

The main alloying constituents are :—aluminium up to 11% and zinc up to 3.5%, both are strengthening agents, and 0.5% manganese increases its resistance to corrosion.

The die casting alloys in most general use are those listed below together with some of their mechanical properties :—

Alloy	U.T.S.	Elongation %	B.H. No.
DTD.59A (As cast)	13—15	6—10	50—60
DTD.289 (Heat-treated) ..	15—18	10—15	45—55
DTD.136A (As Cast) ..	11—14	2—5	55—66
DTD.281 (Heat-treated)	14—18	7—12	55—65

NOTE.—DTD.289 is the same alloy as DTD.59A but in the heat-treated condition, likewise DTD.281 is the same alloy as DTD.136A but heat-treated.

At sub-normal temperatures as low as —60°C., the mechanical properties including the impact strength are generally substantially the same as at room temperature. At elevated temperatures there is a marked falling off in mechanical properties at above 150°C.

In normal atmospheric conditions surface corrosion is not serious, particularly when pressure cast, but protection by the chromating process is always recommended. Sea water attack offers special difficulties, but under certain conditions can be catered for.

Interdentritic cavitations or micro porosity usually to be found in heavy sections when not properly fed can seriously weaken

magnesium castings. When designing a magnesium casting the avoidance of local heavy sections should therefore be a guiding principle. Uniform or carefully graduated sections should always be aimed for. This of course is good advice for castings in any material, but is particularly true in the case of magnesium.

Allowance of ample draft should be made on the skeleton type of castings. The material immediately after solidifying is " hot short " and weak, with the result that cracks, incipient or otherwise, may develop.

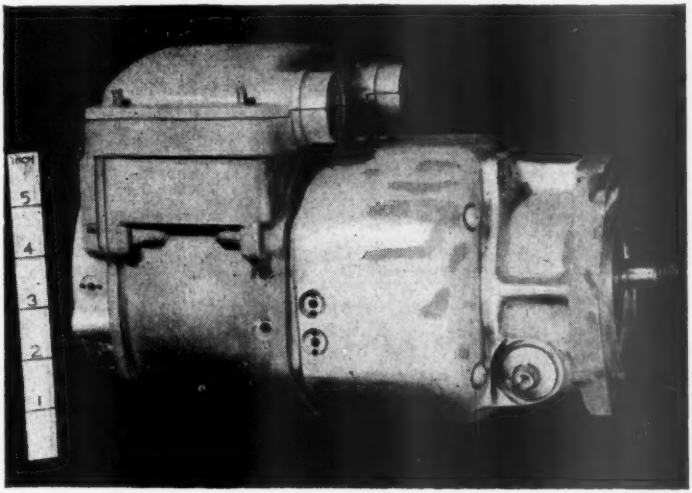


Fig. 14C.

Despite the limitations of the material in matters of strength at elevated temperatures, corrosion and certain inherent production difficulties, it should be remembered that :—

(a) It has the greatest strength/weight ratio of all cast metals.
(b) That it is even now in its infancy so far as development and application is concerned and that we can confidently expect greatly improved general properties in the future.
(c) Above all, it is the only entirely 100% home produced light alloy in present day production.

Design Recommendations.

It is all too often that the die founder is approached for castings to drawings specifying alloys chosen from tabulated properties

probably derived from sand cast test bars, which, as previously mentioned, may bear little or no relationship with the results that will ultimately be obtained from the intended die casting. Also moulding draft may be omitted and probably impossible dimensional tolerances specified. Such drawings, and they are unfortunately quite common, are obviously prepared and approved by individuals

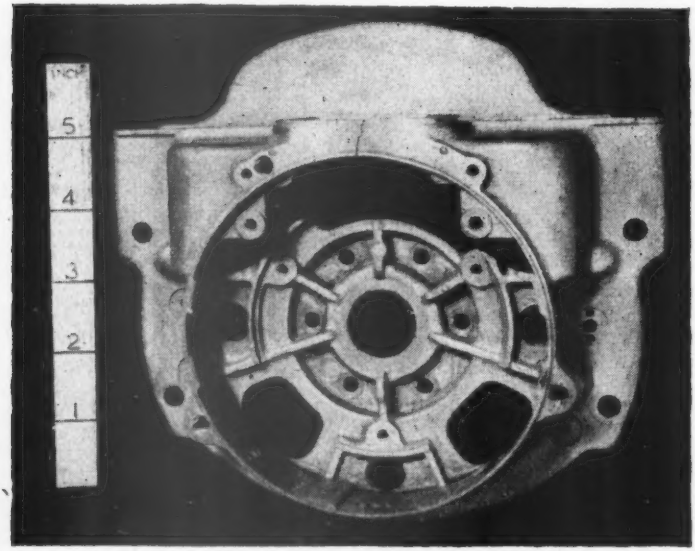


Fig. 14D.

devoid of first-hand knowledge of modern foundry methods. Oft times when attempts are made to mend matters we find that because the prototype was satisfactory on test, (it was of course usually made from sand castings), the drawings are sealed and no changes, or only those of a very minor character are permitted.

It would seem there are many designers who at the best have an elementary knowledge of sand foundry essentials and design accordingly, and then specify a die casting without first consulting the die founder, not realizing probably that he has an almost entirely different set of fundamentals to observe. The die casting is usually specified with the view to reducing prime costs and as a means of minimising machining. These objectives are invariably achieved if comparison is made with a similar sand casting and with

it many consumers would appear satisfied. This approach is wrong, for the foundry could, with their assistance, increase output rates, improve dimensional accuracy, reduce weight and subsequent finishing costs to the barest minimum. It can also offer improved surface finish, compactness, improved lines, of form and stylo in cast assemblies.

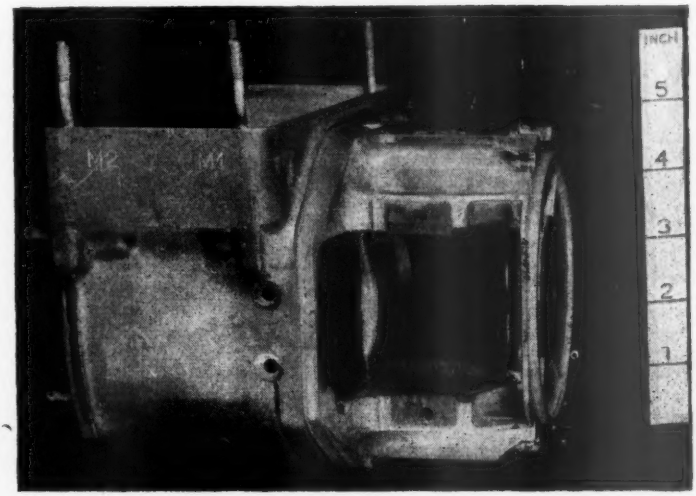


Fig. 14E.

The utilisation of the following features of the die castings can be of substantial service to most designers.

(1) Holes can be cored to any desired shape. To drill anything other than a round hole is a difficult matter, and designers, because of this, tend to specify round holes, whereas die cast holes can be to any preferred shape.

(2) Similarly, spigots, male and female, can be cast to fit, without machining, to almost any shape, symetrical or otherwise. This also is often overlooked because the designer is trained to think in terms of machining.

(3) Wall thickness may often be maintained to within —.003 in., and therefore the designer's safety factor, which frequently allows for the variations expected of a sand casting, should be adjusted accordingly. It is the application of the above features that may frequently result in a more compact project of improved shape.

(4) Die casting may be a means of bonding two or more articles together and be substituted for the more conventional methods of bolting, rivetting or welding. An example is to be found in the steering wheel where the spring wire spokes are included in the hub casting. (See Fig. 12).

(5) Inserts may be embodied in die castings, particularly the pressure variety. Examples are to be found in the previously mentioned die cast gear assembly, wherein the hardened steel shafts of the crown wheel, the bronze bearing bushes, and two cadmium plated studs in the casing are all cast in position. The lever is also cast on to the outer end of the hardened steel clutch striker shaft.

(6) When die castings are substituted for fabricated assembles it is usual for strength and rigidity to be increased (see Fig. 11), whilst weight and costs are reduced. Also with many fabricated components, design scope is limited in matters such as adequate material for bearings, tapped holes, abutments and ribbing, etc. because of the difficulties encountered in rivetting or welding; with the die casting however these can all be readily catered for in an integral unit and when pressure cast in magnesium will generally show a saving in weight.

Evidence of design and production co-operation is strikingly exemplified by the illustrated radio chassis and magneto castings of German manufacture, salvaged from enemy aircraft (see Fig. 13 A and B, and Fig. 14 A to F). The magneto design is worthy of a little detailed examination, and it should be noted that its mounting is such that it is overhung on the engine and subject to severe vibration, therefore the main supporting casting is produced as an aluminium gravity casting of generous proportions including a heavy securing flange. The magneto proper, which is attached to the aforementioned casting, involves the use of four other castings, none of these being highly stressed. All are produced as pressure die castings in a magnesium alloy, and provide an extremely light assembly, thereby reducing the overhung weight and stress on the mounting brackets.

Wall thickness of the magnesium castings are in the order of 2 m/m and in all cases their design has either entirely eliminated or reduced to a minimum, withdrawal pieces in the die. This has the effect of minimising die costs, increasing the rate of production, facilitates improved accuracy and reduces fettling costs. The laminated induction stators are cast in position and the terminal cover is in two castings, aiding both wiring and casting production. Of the end casting particular note should be taken of its extreme lightness and attention paid to detail. Another point of interest is the unusual peripheral shapes of the

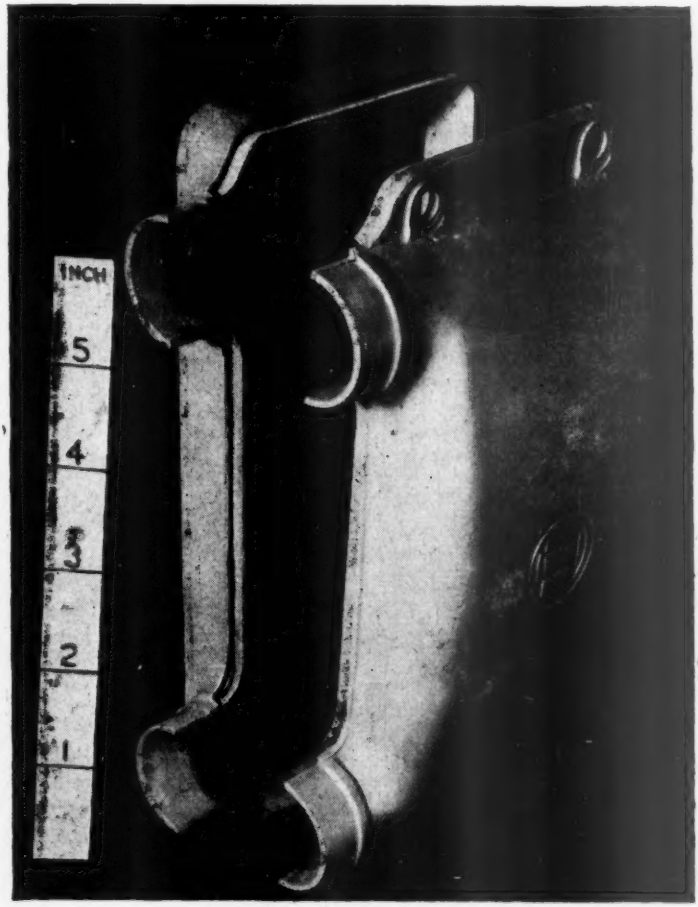


Fig. 14F.

Figs. 14B, C, D, E, F.—Further views of magneto assembly shown at Fig. 14A. The castings were salvaged from a crashed enemy plane, this is responsible for the damage apparent on some of the castings.

The castings are all produced by the pressure casting process in magnesium with the exception of the one with the broken flange which is a gravity casting in aluminium.

Note cast in induction stators in Fig. 14E.

(By courtesy of M.A.P.)

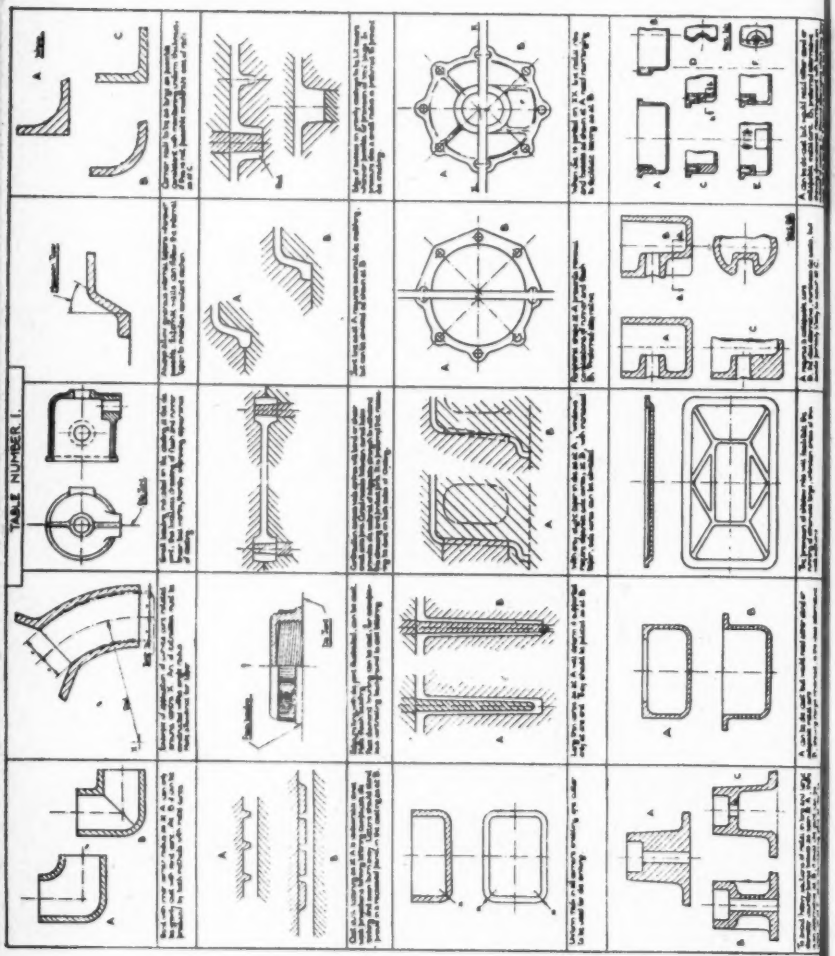


Table 1.—Recommendations for design of diecastings

tongue and groove sealing joints, these present no die casting difficulties, but could not readily be machined.

Fortunately examples of this kind of design, production and foundry co-operation are to be found in this country, as is evident from some of the illustrations, but it is desirable that the practice should be considerably extended so that every die casting design is thoroughly vetted to ensure complete fitness of purpose before the tools are laid down.

A number of design hints that may be termed of a geometrical nature are set out in Table No. 1. It is hoped that these will be self explanatory and that in conjunction with the following summarised recommendations will prove to be helpful when die-castings are being considered.

(1) That if lightness is the paramount consideration then a magnesium pressure die casting is indicated, size and shape permitting.

(2) If the strength/weight ratio is of first importance, thus inferring that the casting shall be free from all traces of porosity and that it is to be fully heat-treated, then a magnesium gravity die casting is needed.

(3) If in addition to the conditions of service referred to in the above two instances, the castings are to be exposed to severe corroding conditions, then the aluminium alloys should be chosen. Or if subjected to high stresses at elevated temperatures an aluminium gravity die casting is indicated to realise the potential strength of the material obtained by full heat-treatment.

(4) If the casting is to be pressure tight an aluminium pressure casting may be satisfactory, especially if it can be arranged that the cast skin is not disturbed. A gravity casting is usually a safe alternative.

(5) If the casting is not too highly stressed and is used at normal temperatures then aluminium, magnesium or zinc alloys can all be considered in the pressure cast form. Desired surface finish, resistance to corrosion, weight considerations and the amount of subsequent finishing operations and prime cost of casting are other deciding factors. Should the quantities be too small, dimensions or weight accessive for pressure casting, then gravity castings in magnesium or aluminium are the alternatives.

(6) If because of other considerations the pressure process is decided upon and that freedom from porosity is an essential, be assured that an adequate pressure casting system is employed.

(7) A pressure casting system should always be used in preference to gravity where high rate of output together with lowest costs are the principal factors. This is true of all the die castable alloys, with the possible exception of brass, etc.

(8) Where accuracy in the " as cast " state is the chief consideration, then again a pressure casting should be employed.

(9) If cast internal threads are essential then use zinc base pressure castings. It should be mentioned that cast threads are not always the most economical. They are often specified only as a means of easing congestion in the machine shops.

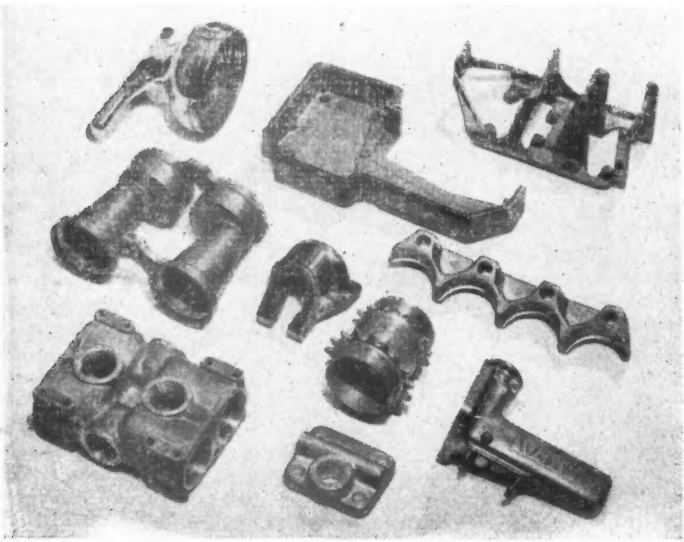


Fig. 15.—Group of typical aluminium pressure die-castings.

(10) Remember that heavy sections can usually with advantage be substituted by I sections, channel sections, judicious ribbing or by a corrugated form.

(11) Avoid rapid changes of section.

(12) Heavy sections can usually be dealt with satisfactorily at one end of a die casting, but not always at both ends.

(13) Consult the foundry on the alloy to be used if there is no previous experience available with a similar component.

(14) Avoid under-cuts.

(15) Collapsible metal cores can be used both with the gravity and pressure die casting processes, but it is strongly recommended that they be avoided wherever possible when pressure castings are contemplated.

(16) Sand cores may be used with the gravity die casting process, but not with the pressure process.

(17) That probably by splitting up a casting into two or more pieces undercuts may be avoided or heavy sections be dispersed, this may often lead to a cheaper and stronger product.

(18) By doing the reverse to that advocated above, i.e., by making two or more castings as a single component, it may often be cheaper, lighter and stronger.

(19) Do not assume that when pressure die cast all dimensions will be to fine tolerances, these are dependent on location of die joints and maintaining correct positioning of moving cores.

(20) Discuss jigging points with the foundry to avoid edges and surfaces thus used being employed for running and riser purposes.

(21) Disclose beforehand faces to be machined, to enable ejector pins, runner and/or risers to be positioned thereon, so that ultimately all traces of them will be removed.

(22) In similar materials and of a suitable size, pressure die castings are cheaper than gravity castings. Die costs, however, are higher.

(23) *Wall Thickness.*

(a) Aluminium gravity castings ...	$^1/_{10}$ in. minimum if in alloy of high content silicon, e.g. L33. $\frac{1}{8}$ in. minimum in other alloys.
(b) Magnesium gravity castings ...	$\frac{1}{8}$ in. minimum.
(c) Aluminium pressure castings	$^1/_{16}$ in. minimum if in alloy of high silicon content. .080 in. in other alloys.
(d) Magnesium pressure castings	.080 in. minimum.
(e) Zinc base pressure castings ...	$^1/_{16}$ in. minimum.

The above figures are representative of the usual run of die castings with total wall areas not exceeding approximately 59 sq. in.

Considerably thinner sections are practicable for smaller areas under favourable conditions, e.g., ·015 in. to ·020 in. for areas not exceeding one or two square inches when pressure cast in zinc base, and .030 in. in aluminium.

Pressure castings should never exceed $^3/_{16}$ in. general wall thickness in any material, especially if they are to be pressure tight and free from porosity.

There is no reasonable limit to the maximum section of a gravity casting, providing it can be adequately fed from the riser during the period of solidification.

Finally, although it will be realized that of necessity these recommendations and other considerations that have received mention are of a general nature and while their application will beneficially

improve the design of die castings to obtain the maximum benefit of the many potential advantages the process offers, full design co-operation with the die founder is strongly advocated.

Discussion

THE CHAIRMAN, when declaring the meeting open for discussion, said that Die Casting was an example of the principle, so important in the science of production engineering, of bringing the raw material as near as possible to the finished size, without, as it were having to hew the article from the solid. The lecturer, however, had made it quite clear that in order to take full advantage of the Die Casting processes, the Die Casting expert should be called into consultation while the job was in the design stage.

MR. FARRER opened the discussion by saying :—

(1) Since by the "Gravity" method of Die Casting, parts possessing superior physical properties are obtained when and why should the "Pressure" method be employed ?

(2) Since "Gravity" Die Casting seems so much more reliable than Sand Casting, does this mean that Sand Casting of metals suitable for Die Casting will eventually "die out" ?

(3) He found some Die Castings difficult to machine particularly those made from L 33 Silicon alloy, could the lecturer offer any explanation ?

(4) It seems that to some extent Die Pressings (or forgings) are preferred to Die Castings. Die Pressings seem to offer certain advantages, e.g., metal more homogeneous ; less metal required ; no runners needed, and less heat required. He knew of cases in U.S.A. where parts previously Die Cast were now Die Pressed for preference.

MR. FAIRBAIRN : (1) The Gravity method certainly produced castings having better physical properties but there was an enormous scope for the pressure method where high physical properties were not essential, but where minimum weight "as cast" accuracy and low initial cost of casting were important considerations.

(2) Castings up to 120 lb. in weight are now made by Gravity Die Casting, but the outlook for sand casting is by no means gloomy as the majority of the large and more intricate castings for large aircraft and diesel engines are still made by sand casting.

(3) At the present time there are many instances of de-graded alloys and probably "inclusions" adversely affects machineability. Machineability is very largely dependent upon alloy used, e.g., alloys with copper or magnesium hardeners such as L8. or Birmabright have excellent properties and with L.8 particularly

an extremely high degree of surface finish is readily obtainable. Silicon containing alloys such as L.33 are however, more difficult to machine as the metal tends to tear and also to adhere to the cutting tools. All of the aluminium alloys are relatively free cutting, therefore ample chip clearances should be provided for and the cutting edges should be very highly polished to prevent adhesion.

(4) Die Pressings versus Die Casting.

Parts made by "Die Pressing" or "forging" usually had mechanical properties slightly better than obtained by the usual die-casting methods but with the improved die-casting processes now available there is little to choose between the two. Die cast aero cylinder heads were cited as examples.

Die Pressing was considerably more expensive. In Die Casting the runners and gates were readily remelted with a melting loss of about 2½%. Although unable to quote actual figures it was true to say that considerably more heat was required for production of Die Pressings, e.g., ingots had to be converted into billets, the ends of which were removed and these together with the swarf made when machining the surface involves considerable remelting.

The final billet is then reheated for extruding. The first part of the extrusion is invariably unusable and is returned with the remains of the extrusion billet slug for remelting. Finally suitable lengths of the extrusion are preheated several times to produce the die pressing or forging which also has a fairly considerable amount of "spue" of flash that is ultimately remelted. So that all told a a very considerable additional amount of heat is expended in producing a forging as compared with die casting.

MR. MATTHEWS: Can Die Cast parts be readily "Tapped" for screw threads?

MR. FAIRBAIRN: It depends largely on the process employed for producing the Die Casting, viz:—

Gravity	Yes.
Pressure Cold Chamber	Yes.
Pneumatic Hot Chamber or Direct Air Blown	Doubtful.
Hydraulic Hot Chamber Pressure	Most likely.

MR. COX: Which is the best type of Die Casting Machine for dealing with the alloy known as Mazak, low pressure or high pressure?

(2) Does the high-velocity of the metal in the high pressure machine have an adverse effect on the dies?

MR. FAIRBAIRN: (1) I recommend the use of the Hot-Plunger Hydraulically operated machine giving a pressure of about 1,500 lb. per sq. inch.

(2) High pressure does not necessarily mean high-velocity. Velocities can be sensitively controlled when hydraulics are employed. Whatever type of machine is used, properly designed and well made dies are essential for a good quality product.

MR. DONOVAN asked, (1) For particulars of electrical-conductivity of Die-castings.

(2) Are Die Cast parts suitable for "shock loading"?

(3) Can "inserts" be used in parts made by Gravity process?

(4) What is the minimum economic quantity when considering Die Castings?

MR. FAIRBAIRN: (1) Particulars are readily available.

(2) There are a number of suitable alloys, conditions of service, temperature, etc., should however, receive consideration.

(3) Inserts are used but I do not like them used with the Gravity process particularly if they are small in size.

(4) Minimum economic quantity depends on process namely:—Gravity Method—500 approx. or if very simple shape 250 approx.; Pressure Method—5000 approx. for a reasonably simple shape, 10,000 approx. for a complicated part.

An approximate comparison of die cost between Gravity and Pressure methods are about 60 Gravity to 100 Pressure.

MR. BRADFORD: (1) How is "artificial ageing" of Mazak 3 carried out?

(2) How are the magnesium alloys prevented from "catching fire" when melted?

MR. FAIRBAIRN: (1) The parts are held at a temperature of about 100°C. in a dry atmosphere for 3 to 4 hours.

MR. FAIRBAIRN asked a colleague MR. DOWLE to reply to number 2.

MR. DOWLE: The ignition temperature of magnesium is higher than its melting temperature but as a precaution means are taken to exclude air.

Here the discussion had to be ended on account of the time.

Vote of thanks to Mr. Fairbairn, proposed by Mr. Bainbridge, seconded by Mr. Fellows.

In his response Mr. Fairbairn paid tribute to the help received from his directors and colleagues at the Birmingham Aluminium Casting Co. in preparing his paper.

Vote of thanks to the Chairman, proposed by Mr. Farer, seconded by Mr. Berry.

PLASTICS PRODUCTION

Paper presented to the Institution, Cornish Section on 23rd February, and Sheffield Section on 29th March, 1944, by R. H. Bebb, Esq.

A DICTIONARY definition of the word Plastic is given as " capable of being formed, guided, moulded; pliable, impressionable." This of course, is a wide description which may be applied to many substances such as pitch, pottery, cement, glass, various metals, etc., but the applied modern meaning of the title Plastics embraces those materials (excluding rubber) which have for a base a natural or synthetic resinous substance to which may be added fillers (wood flour, paper, asbestos, etc.), plasticisers, dyes, hardeners, lubricators, catalysts, etc., and in their combined form are processed into a powder which may be brought to a final product by the application of heat or pressure or both.

It is probable that the manipulation of natural resins (e.g., secretion from pine trees and certain insects) for weather resisting

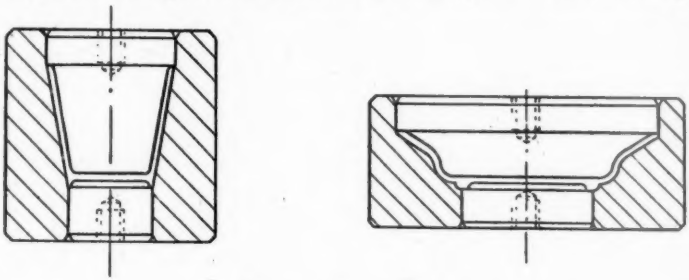


Fig. 1.—Positive moulds.

films and the desire for synthetic substitutes led to discoveries in plastics as they are known today.

Early development gave us materials which would melt at any time by the application of heat; these are now termed thermoplastics. Records show that decorative jewellery boxes were manufactured from shellac base material at about the middle of the nineteenth century: gramophone discs of the same material were made towards the end of the century. At the beginning of the twentieth century processed milk plastics were discovered; developments in other spheres (literally spheres,

for the material was used as a substitute for ivory in billiard ball manufacture), resulted in numerous plastics of the cellulose acetate type.

A parallel development of similar nature but with a totally different result, gave us plastics which would not remelt after processing. These materials are termed thermosetting and are often erroneouly given the name Bakelite.

The majority of thermosetting resins are either an extraction from coal tar (phenol, cresol, etc.) or a combination of gases including ammonia and carbon dioxide (urea) with a hardener

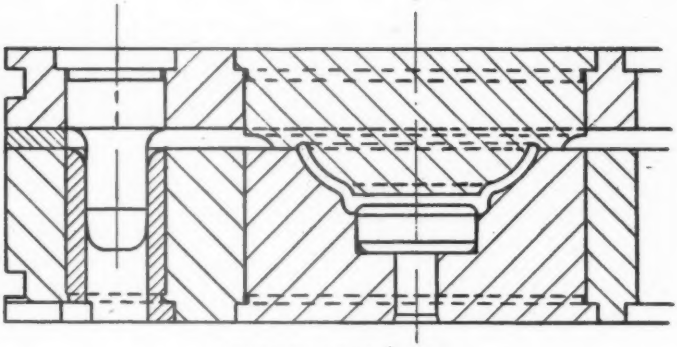


Fig. 2.—Open flash mould.

obtained as a bi-product of producer gas (formaldehyde). Many thermo plastic resins are extracted from cotton.

Hundreds of variations of synthetic resins are known and numerous commercial applications used, but the object of this article is to give a brief survey of the processing methods of the plastics production engineer and we shall consider moulding by :—

(1) Compression. Material compressed between formers.
(2) Injection. Material injected in a plastic state into formers.
(3) Extrusion. Material squeezed through dies to produce continuous sections.

A fourth process termed transfer moulding concerns thermo setting material only. With this exception the above methods of moulding can be applied to both classes of material.

Tooling for Thermosetting Material.

(1) *Compression Moulds.*

The various constituents of thermo plastic materials for a given resin vary in a comparatively small degree but with

the thermosetting materials we find fillers such as paper, wood pulp, asbestos, wool flock, resin impregnated linen, canvas, etc., all of which have their specific uses and effect tool design mainly relative to loose powder accommodation, since bulk ratios of powder to finished article vary from $2\frac{1}{2}$: 1 to 15 : 1 according to filler.

A pressure of up to 2 tons per square inch of moulding area, a heat of approximately 300°F., a very good surface finish and facilities for rapid handling, should characterise a moulding tool. Pressure is usually obtained from hydraulic machinery and sometimes by toggle and screw presses. Heating is by steam, hot water, gas or electric hot plates fitted above and below the moulds, but large tools have integral heating elements. Lagging tends to increase efficiency and even aluminium paint on the outside surface

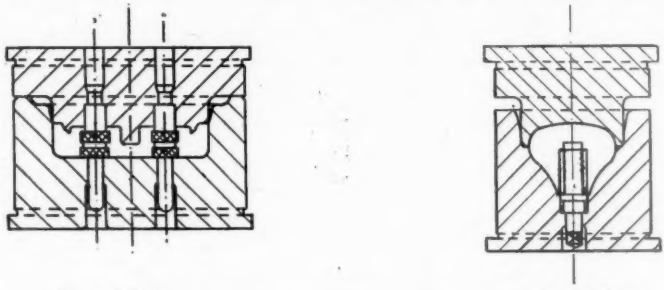


Fig. 3.—Semi-positive moulds.

makes a useful contribution towards this end. Moulding cavities and adjacent faces must be highly polished and where phenolic and urea plastics are used alternately in the same moulds chromium plating is essential : it is also desirable where urea plastics only are used.

For the production of sheet material in plain, sandwiched colours or veneers, the simplest type of tool is needed. Paper sheets are impregnated with resin, dyes, etc., and after drying out are laid between steam heated hot plates and compressed at a constant temperature for a definite period after which the material sets quite hard and can be removed from the press in a hot state as indeed are all thermosetting plastics. In order to prevent excessive warping, however, the steam is turned off and cold water passed through the hot plates ; the finished panels are then removed flat and cold. Large flat trays are made from similar material and cooled before removal from the press. With these exceptions thermosetting moulds are maintained constantly at a definite temperature.

The first three diagrams represent common types of compression moulds, which are known as positive, open flash, and semi-positive moulds respectively. The first is essentially a single cavity tool where the moulding thickness depends to a large extent upon the amount of material charged in. The second may be multicavity type and is very successful for thin shallow articles, provided substantial alignment dowels are incorporated. The third type is widely used throughout the industry. The provision of an additional cavity above the moulding line is to accommodate bulky

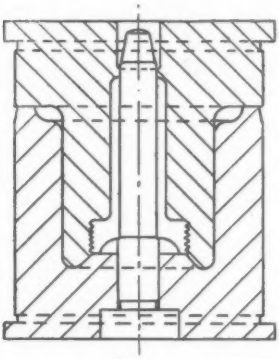


Fig. 4.

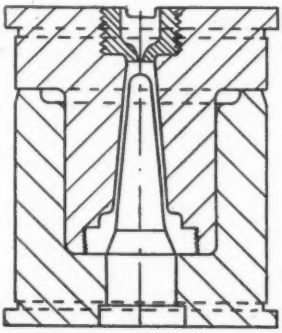


Fig. 4a.

Displacement moulds.

powder. Semi positive horizontal flash moulds are most suitable for thin mouldings, but for thick sections and especially for fabric material, veritical flash is preferable. A space between punch and die of about .001 per inch of diameter and escape grooves, or tapered relief for multi impression moulds is most important, as this allows excessive material which may be inadvertently loaded in one cavity to escape, otherwise damage due to concentration of pressure may occur.

For horizontal flash tools, the land faces should be kept to a minimum, and auxiliary stops incorporated to prevent damage.

Figs. 4 and 4a, illustrate a displacement tool designed to obviate the bending tendency of slender cores; this design proves equally successful in both cases indicated.

Under the action of the decending punch, moulding material is displaced upwards, driving in front of it air and gas from the powder. This must be allowed to escape, and as shown in the diagram air vents are included at the highest points.

Both methods of venting as shown are successful and provided care is taken in tool making, both are easily cleaned. Dis-

placement tools for full fabric material are not successful unless the centre pin is arranged to move upwards and make a vertical cut off after the punch has completed its stroke.

(2) *Multi-plate Moulds.*

Figs. 5 and 6 show how the aforementioned methods of moulding may be varied or combined to overcome certain difficulties, for example, the production of a thin cylindrical article having an external central collar. With a two piece tool, difficulty in excluding air and gas trapped between the central core and the punch often causes a large percentage of poor mouldings.

With three (or more) plate designs the production of clearly defined and definitely positioned two colour mouldings is possible,

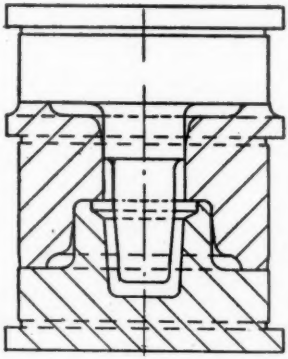


Fig. 5.

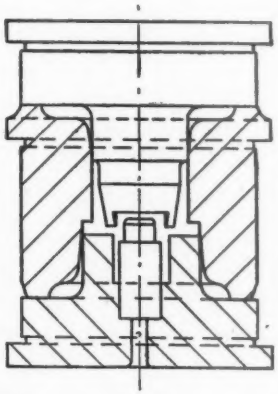


Fig. 6.

Three plate moulds.

insert loading, screwed component manufacture, moulding extraction and mould making is often facilitated but consideration must be given to the tendency present in many designs for the middle plate or plates to lift and allow material to escape through the lower contact faces.

If the area of the lower punch is greater than that of the top punch, then vertical cut off for the former is preferable. If the moulding is bulky or requires a high pressure to drive the material through narrow channels, then vertical cut off is essential unless the designer modifies the upper punch to a horizontal cavity equal in area to the lower member, turns the tool upside down if powder accommodation is suitable or arranges additional pressure devices to operate on the middle plate only.

(3) *Manipulation of Fabric Sheet.*

We have already mentioned fabric filled powder but in some cases fabric sheet is stronger ; here mouldings of uniform thickness are desirable but not absolutely necessary. It is usual to have vertical flash moulds for cutting off purposes, but this is not essential as the general practice is to cut the material to shape and size before moulding.

Much care is taken in selecting blanks for mouldings having webs, bosses and varying sections. The blanks when developed are sewn or stapled together for convenience in handling.

A simple blanking tool may be made by marking out plywood and cutting with a fret saw leaving suitable ribs to ensure that the centre remains in position, and inserting pieces of sharpened steel strip. The tool may be fastened in a light press and used in the usual way. Mouldings fabricated from sheet material are very strong indeed.

(4) *Pins and Loose Pieces.*

As a rule the fewer parts to a moulding tool the better the results, since no matter how carefully the loose parts are fitted a joint line will show on the moulding. Furthermore, the slightest deflection of metal round the loose piece will allow flash to creep down and increase the width of the joint line. For this reason the use of vertical joints wherever possible is important. If horizontal joints are used adequate clamping devices are essential. This has already been mentioned in another form in remarks relating to three plate moulds.

Removable loose pins should not be used in punches unless unavoidable, in which case care must be taken in designing suitable retaining devices.

Regard side pins as undesirable unless they are either short or exceptionally sturdy.

The usual type of mould pins are shown in Fig. 7 and the following remarks are worthy of consideration.

(a) Shows a valve seated pin. This appears to be particularly effective ; this is so, for large pins which may be ground on the seating of pin and mould but for small pins there is difficulty in producing a correctly fitting pin. Even good fitting pins have been known to lift during moulding and should not be used where there is tendency towards axial flow as in the case of pins in the lower part of a displacement mould. Valve seated pins are advantageous when a small thickness of metal only is permissible round the shank of the pin as in the case of pins near the corners of punches, pads and the like.

(b) The Shouldered Pin is recommended being easy to make

and fit. There are few cases where valve seated pins are more efficient than shouldered pins.

(c) Shows a Spring Pin for inserting in punches.

(d) Is similar but not so effective.

(e) Often proves troublesome as do spring loaded balls and plungers fitted into the actual mould for retaining purposes.

(f) A positively latched pin retained by means of a slotted plate is the most reliable of all.

(5) *Extraction.*

We have considered tooling methods but no mention has been made of methods of stripping the mouldings from their tools.

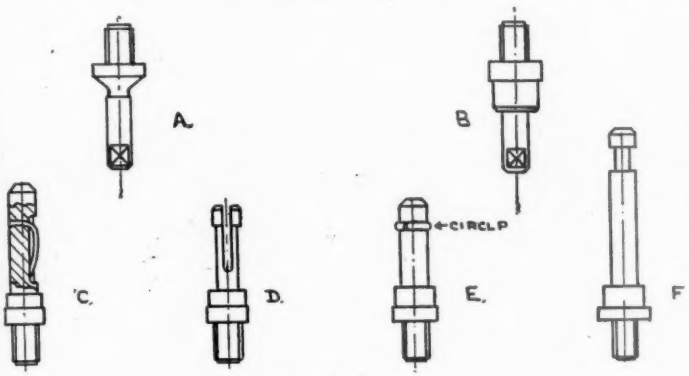


Fig. 7.

Incidentally, stripping as applied to press tools is a common method of moulding extraction. Tools must be obviously of a multi plate design and are very efficient. Stripping may be used to remove shallow threaded mouldings having an internal thread.

Other methods of extraction are :—

(1) Air blast for simple shapes, generally used in conjunction with open flash moulds.

(2) Electric and pneumatic guns for threaded components.

(3) Knockout pins either manually or automatically operated with spring or hydraulic return mechanisms.

(4) Special bench fixtures for isolated cases.

Fig. 8 indicates an automatic ejection arrangement.

Methods of operating tools differ, some manufacturers insist on having fixed tools, whilst others use tools which are taken

from the press for ejection and reloading, generally two moulds are worked simultaneously. Both methods have their values. and the compromise in the form of a rail system results in most of the advantages of both arrangements.

(6) *Split Tools.*

All the moulds so far described, produce articles which may be withdrawn without difficulty. It often happens however, that this desirable state of affairs does not exist, due to protruding or recessed portions causing undercuts and moulding extraction is only possible after withdrawing the side pieces or by using a split mould. Whilst punch undercuts are often successfully overcome, tool design in this case is most critical. Small undercuts may be "sprung" off, larger ones may be overcome by the use of formed ejector pins or removable loose pieces.

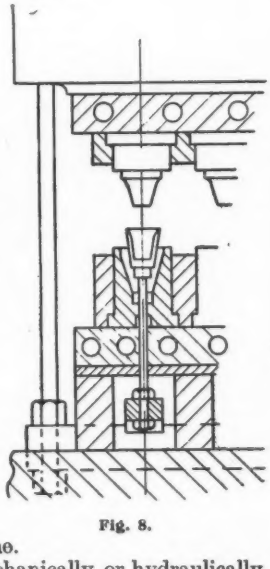


Fig. 8.

Two main split mould methods are common.

(1) Indirect side pressure obtained from tapered splits : often used where one vertical joint line is necessary : frequently used for more than one joint line.

(2) Direct side pressure obtained mechanically or hydraulically. Most efficient for one vertical joint ; seldom used for more than one joint.

Let us consider the most common cases of splits, that is one vertical joint only. For simple or small multi impression tools, tapered removable splits are most economical, especially if the splits are conical. Duplicate splits speed up production ; one may be discharged whilst the other is moulding, i.e., the method applied to most hand moulds.

It may appear that duplicate loose splits give a greater rate of production than power operated fixed splits and the economics of loose splits considered preferable, but much depends upon correct application and design. A mould well designed and incorporating power operated splits may be considerably smaller than the size of a tapered bolster containing a like number of cavities.

If the punches are assembled on bars of the same width as the die splits and each bar arranged to slide in the same

direction as the dies, very rapid moulding extraction may be accomplished by partially withdrawing the punch plate ($^1/_8$ in. or so to remove the vertical pressure) and then opening the splits. The mouldings are taken up on the punches and if a rail system, to incorporate a tipping device is used, extraction is particularly simple. Fig. 14 shows a sliding punch split mould.

A tool designed in the manner described is often faster and cheaper than a tapered split mould. Duplicate punch plate assemblies often give a greatly increased production.

The initial cost of a hydraulic side ram and fitting is, of course, high and may be prohibitive if included as a tool costs, but since any similar tool may be used in the adapted press, then the cost may be assumed to be a plant charge. Presses are obtainable with side rams included in the structure but in some cases the stroke of the rams and the space available for the mould layout is very restricted. There are however, some very good designs available having one side ram and adequate mould space which may be used for operating split moulds or ordinary two or three plate moulds as and when required.

As a summary to the above remarks, the writer advocates that a modern plastics plant should have a high proportion of side ram presses. The additional extra plant charge would undoubtedly be offset by the scope and economy in producing mouldings which tend to become more complicated as the value of plastics is appreciated.

(7) *Injection and Transfer Moulding.*

In the preceding paragraphs we have dealt with average compression moulding procedure. It will be obvious that when subjecting intricate mould shapes to pressures in the region of two tons/square inch there is a great tendency for distortion to take place on slender sections which may be unevenly loaded by pressure transmission through unplasticised material. This is the inherent disadvantage of a compression mould : if the load can be changed into fluid pressure any bending force is neutralised and a compression load applied which the material of the mould can easily resist.

This is precisely the principle of transfer and injection moulding, the only difference being that in the former case the plasticising chamber is built integrally with the mould whilst in the latter case the chamber is carried separately and connection between chamber and tool is by a spherical or conical nozzle. In both cases the material is plasticised in the chamber and forced through small apertures into the mould cavity at pressures varying from 5 to 10 tons/sq. inch and higher, 22 tons/sq. inch have been successfully used. Air and gases are driven in

front of the material through suitable vents. These pre-plasticising arrangements are essential when weak tool sections, slender core pins or long inserts are met; and can also be used with advantage in the production of very thick mouldings where the passage of material through narrow spaces ensures that uniform

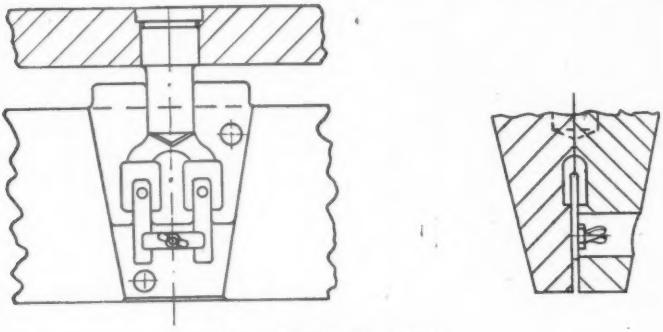


Fig. 9.—Split transfer Mould.

heating takes place. This fact is more appeciated if we bear in mind that plastics are poor conductors of heat.

In transfer moulding we find three main methods are practiced in each case plungers and chambers are built integrally :—

(1) Horizontal flash (often open flash) employing three or more plates.
(2) Split moulds either tapered or power operated.
(3) Employment of additional central ram, built into a standard press.

The latter method the writer prefers to call Semi-Injection as all the essential mould parts are almost identical with an Injection tool proper as a later description will show.

No. 1 may be likened to a three plate tool where the upper punch registers in a " blind " parallel sided cavity in the middle plate, which has cut on the lower side the moulding form with straight connecting channels to the previously mentioned cavity. The bottom punch may core the moulding in the usual way. The area of the top punch or plunger must be greater than the flash face of the tools, as the closing force is only obtained by virtue of the pressure transmitted through the moulding material in the upper cavity.

In No. 2, a similar state of affairs exists but closing pressure is obtained by means of tapered splits in the example indicated in diagram (9). For simple splits this is preferable but for

larger and more complicated shapes, use of a side ram press is desirable.

Semi injection moulds are similar to horizontal flash transfer moulds, but the plunger runs right through the plunger plate and closing force is obtained by means of an independent ram. Diagram (9a) shows a salient feature of this design.

Thermosetting injection moulding as generally used, consists of a separate pot and plunger connected to the split line of taper or power operated splits by means of a conical or domed nozzle. There is a tendency towards the use of thermo plastic methods

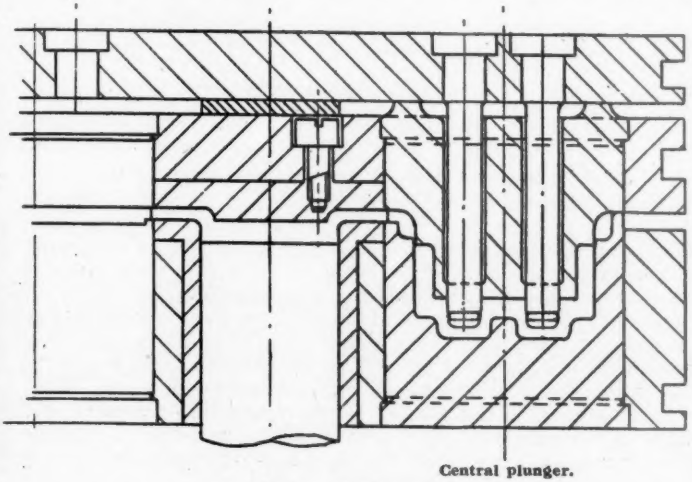


Fig. 9a.—Transfer mould.

of injection and since the principles are almost identical (the exception is that thermosetting tools are kept at approx. 300° F.) a general description given later is common to both types of injection.

Thermosetting materials will flow through extremely small spaces, because of this all types of plungers are generally run cooler than the mould temperature in an effort to reduce material escape between pot and plunger.

In all methods of injection and transfer tools the projected area of the land face and moulding cavity multiplied by the pressure per unit area must not be greater than the available closing pressure. For this reason it is advisable to relieve contact faces

to within say $^3/_{16}$ in. of the mould cavity. Under these circumstances auxiliary stops of generous proportions must be included elsewhere.

The operation sequence for this class of mould is as follows, cylinder is loaded, tools, clamped, pressure applied to plunger, slight pause, material plasticises and is injected into the cavities. There is another pause for cure to take place, press is opened, moulding extracted and all flash, feeder stalks, etc., removed from the mould and cylinder prior to the next cycle.

Preheating the plastic assists, whilst factors tending to defeat the aim are :—

(1) Slow acting injection ram. Possible cause, wrong pipe or stoppage in pressure line. Result, material sets in feed grooves.

(2) Back pressure built up in the tools by trapped air. Provision for venting should be made but carried out only if found necessary. Vent clearing facilities must be made.

(3) Long feeds of small area. Round feeds spreading out to rectangular sections at the point of entry are suggested

Material varying from easy flow, low bulk factory, to semi fabric and even full fabric are injected ; thus it is we may speak in general terms only. An average size of feed at the point of entry for simple shapes is equal in square inches to $^1/_{70}$th of the weight of moulding in ounces with a width of four times the depth. In addition there is the very successful method of feeding bulky mouldings by a narrow aperture arranged all round the periphery. This method is used extensively in transfer moulding.

Feed position is not critical for thermosetting material, and many mouldings have been produced with feeds placed in the most convenient rather than the most scientific position.

Important considerations, however, are :—

(1) Do not feed on slender pins.

(2) Feed with a view to filling the cavity from one end to expel air in front of the incoming material.

(3) Locate feeds in hidden positions on decorative articles.

(4) Avoid abrupt changes in direction.

(5) Do not pass feeds round circular loose pieces.

(6) Arrange for the feed to come away from the tool with the moulding attached.

(8) *Extrusion*.

Production of rods, tubes, sections, etc., in thermosetting materials is not one of long standing.

A description of the tool design may easily be obtained by

studying an example of a tube extrusion tool where the important features are :—

(1) Plunger—operated hydraulically and having a continuous cycle of strokes which may be varied within certain limits.
(2) Loading chamber to contain the material, locally cooled to prevent powder from curing.
(3) Pommel and spreader to form the inner portion of the tube and to ensure that no mould lines are visible.
(4) Curing chamber fitted into a heated bolster.
(5) Slotted end and friction nut to build up back pressure against which to mould.

This latter item is most important for without it similarity

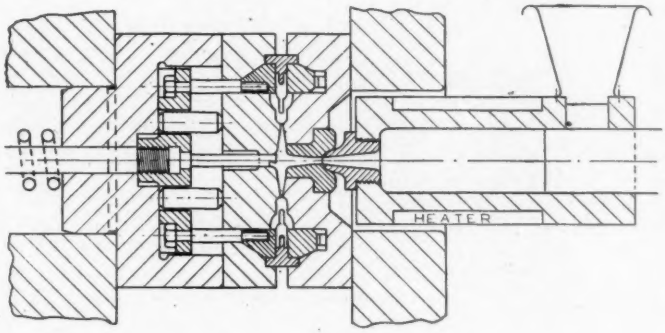


Fig. 10.

may be drawn by attempting to mould in an upstroke hydraulic press if the top cross head were removed. Which is absurd.

Since access to extrusion tools is often required for cleaning purposes, the use of tapered heating bolsters is common ; parallel drive fit portions are not recommended. The writer has found that on certain tools, extraction has been accomplished only after a number of blows with a sledge hammer have been administered in no uncertain manner.,

Round sections cause little difficulty in tool making except where small diameters are required. Other sections often necessitate split tools for ease of manufacture.

More than one section cannot be extruded by means of one plunger working in a common powder chamber and the rule is one plunger for each section.

Fig. 11, shows a general arrangement of a tube extrusion tool. The central core is supported by means of four arms which

are cut spirally to create turbulance in the plastic and to distribute heat obtained by conduction. Another design—which is more simple from the tool making point of view, passes the central core through a sleeve plunger and anchors the core to a fixed part of the machine. Both methods are successful.

Tooling for Thermo Plastic Materials.

(1) *Casein Manipulation.*

Processing of milk resinoid material whilst a well established industry, has not the scope of the more recent undertakings, but manipulation of casein is very interesting.

The first step in production is a consolidation of powder as received from the chemist. This is accomplished by heating

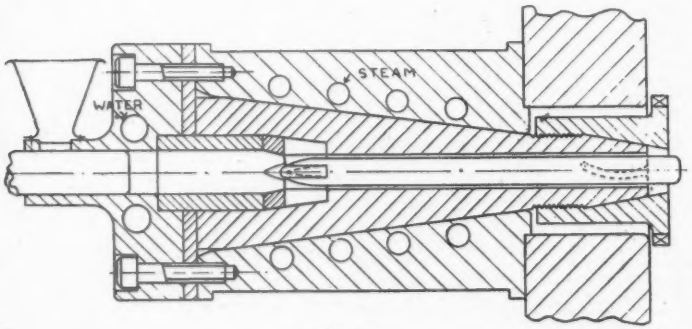


Fig. 11.

and squeezing the material by means of a slowly rotating screw through restricting screens and then through nozzles of suitable shape to emerge as a continuous run of extruded material If the material is required as extruded, suitable lengths are cut, cooled, and submitted to a chemical hardening process. (Immersion in formaldehyde solution for periods of up to 12 months according to thickness).

For sheet production the material is cut into lengths varying from 18 in. for silken finish sheets to nibs of $^{3}/_{16}$ in., for plain or mottled surfaces. The cut pieces are placed in shallow trays, compressed between heated platens, cooled, removed from the press and immersed in formaldehyde as before.

In both cases mentioned the final product is obtained by machining the processed material, after which the articles are polished by chemically softening the surface and then allowing to dry, resulting in a more or less perfect glaze.

Other Thermo Plastics.

(1) *Compression.*

Most thermo plastic materials may be compression moulded by the use of tool formations already described but cooling must take place before the moulding is extracted.

This method is used in few cases only, the determining factors are when thermo setting materials are too brittle or when mouldings are too large for alternative processing methods. An example may be found in the case of a steering wheel, where an ordinary semi positive mould having exceptionally generous steam and water ways incorporated to facilitate rapid heating and cooling. Air inclusions are difficult to eliminate in certain types of compression moulded thermo plastics.

(2) *Injection.*

Compression moulding of thermo plastic is necessarily slow, but when injection methods are applied a very high production rate results, which in many cases is automatic.

The intrinsic feature of injection tools are :—

(1) Plunger and heated injection pot. Nozzle connection.
(2) Cold tools (often water cooled) incorporating automatic ejection.

The diagram, Fig. 10, shows the main points: moulding material is shot into the tools with the probable result that at first contact a hard skin is formed and flow takes place below the surface. With heat radiation the tools warm up locally giving a final result of a mass of material something like a bubble, with a slow moving skin and rapidly flowing internal structure. This fills the mould cavity, cools and produces the required article.

This principle should be considered when determining the most suitable feed point on a particular component. For example, a solid article may be fed from any point but a ring may be more successfully fed all round the inner edge.

With all injection tools, the material pressure (usually 7 to 10 tons/sq. in.) times the projected area of the mould cavity and feed grooves must not be greater than the closing pressure available, otherwise the tools will open and substantial locking devices will be needed. This point must be remembered when designing tools for a manually operated injection press.

The remarks already made regarding feeds for thermosetting injection moulds generally apply with the following exceptions :—

(1) Expansion rather than progressive building up occurs.
(2) Thermosetting material will flow through smaller spaces than will thermo plastics. Land relief is not important.

(3) The mould for thermosetting material tends to keep the material plastic, whilst moulds tend to freeze thermo plastics.
(4) Because of this, long articles with very narrow sections towards the end away from the feed are difficult to produce.
(5) Provision must be made for mouldings, runners and feeds (Sprue) to remain on the side opposite to the nozzle, which from it may be ejected.
(6) Flash films should not appear on joint lines.
(7) In certain materials air inclusions in the sprue cannot be avoided and weakness may occur at the feed point.
(8) Where two streams of material flow round the core and join, poor weld lines may sometimes be overcome by including an overflow channel or riser.
(9) Air vents where necessary are usually larger than those for thermosetting materials. Facilities for cleaning are not usually necessary.

(3) *Extrusion.*

We have already mentioned the screw extrusion machine as used primarily for casein. This arrangement is quite successful for extrusion of the softer and less volatile materials, but for hard thermo plastics, extrusion by reciprocating plunger is generally used.

The principle is similar to thermo setting extrusion but the product moves at right angles to the plunger, this enables the core in the case of tubes to be replaced by sliding wooden rods, metal tubes or another plastic section, with the result that a veneer of extruded material appears on the rod which replaced the core.

This system in a miniature form is used in conjunction with a screw extruding machine to cover wire with a soft thermo plastic insulating material.

The diagram Fig. 12, shows the salient features of a rod veneering set up.

General Remarks.

(1) *Metal for Moulds.*

To any prospective user of moulded plastics, the tool cost is an outstanding item. The rate of production required controls the number of cavities needed. The duration of production, or intricacy of article controls the type of material to be used for mould making. It should be noted that, in tool cost considerations, the difference in material cost of, say, mild steel to non-shrink alloy steel is of secondary importance.

These are broad outlines and much discussion on economical lines could be covered, but the following remarks will serve as a summary.

For inexpensive moulds where short runs are contemplated, non-ferrous metals are sometimes used, e.g., zinc base alloy. An alternative is the use of a close grain cast iron or semi-steel, both of which may be cast closely to size.

For normal moulding runs a case hardening nickel chromium

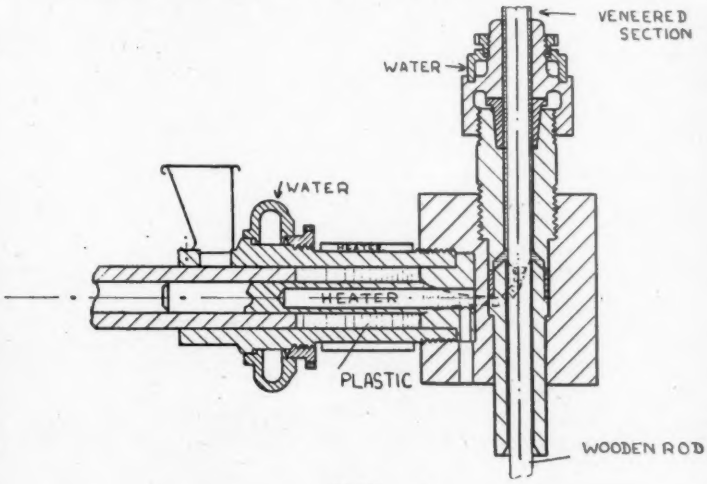


Fig. 12.

steel, is very successful, whilst for long runs or where weak sections are met, a non-shrinking alloy steel is needed.

(2) *Hobbing.*

This process where applicable, simplifies mould making and consists of forcing a hard steel master (often a high carbon chrome steel) into a soft mild steel or iron blank which after hobbing is machined to remove distortion, case hardened, ground and used in the normal way.

This method is invariably used in the production of dies for serrated or faceted bottle caps and the like, but numerous moulds of unexpected difficulty have been made by hobbing.

The largest hobbing of which the writer is aware is a die for a fluted lampshade, having dimensions of approx. 5½ in. diameter × 6 in. deep. Whilst this is not claimed as a record, its production is quite an achievement.

(3) *Screw Threads.*

In the preliminary survey of a new threaded component, the following items should be born in mind.

(1) Avoid threads which run out and leave a knife edge on the moulding tool. This can often be eliminated by including a chamfer at the finish of the thread or alternatively remove a portion of the thread.

(2) Avoid finely pitched threads as they are difficult to polish.

(3) Use rounded threads for unimportant articles.

(4) If the article is unimportant and the thread shallow consider stripping rather than unscrewing.

Having decided upon the thread to be used the outstanding considerations are accuracy, finish of tool and shrinkage of moulding material as it affects the pitch. The first two considerations can be trusted to a good toolmaker who will be assisted by modern equipment which may include a shadowgraph, microscope, etc. The third is often ignored, but can be compensated for by gearing or by various patented arrangements.

Two types of machine may be used for thread milling :—

(1) Adapted lathe having a special slow speed drive for the work, and a cutter spindle mounted on a tool box.

(2) Universal milling machine with dividing head, geared not through the usual 40 : 1 reduction, but direct to the lead screw and traversed by means of auxiliary drive to index plate shaft.,

Both methods are successful, but pitch shrinkage compensation, other than by gearing, can be applied more easily to the lathe than to the miller.

Moulding draw taper is obtained by throwing the lathe headstock or the miller dividing head out of alignment.

For extreme accuracy of thread forms and for the elimination of polishing and bench work, thread grinding may be employed, to produce external or large internal threads. Here pitch shrinkage compensation is difficult, and hitherto very little known progress has been made in this direction.

(4) *Finishing.*

The moulding operation is the first and most important in the production of plastic components. All mouldings, however, require some form of finishing.

The removal of joint lines (de-flashing) is universal. Round articles such as plates, cups, switch covers, etc., are often spun and filed ; rectangular articles are bench filed ; small articles barrelled with wooden pegs, whilst full fabric plastics are often clipped on hand presses. Linishing is quite successful for articles having vertical flash.

Polishing to remove scratches is necessary after all the above operations except barrelling, where wax included amonst the wooden pegs performs the operation automatically.

The aforementioned are applied to nearly all mouldings, but the following operations are necessary in particular cases only.

Drill jigs of simple nature are used. Bridge thinned drills

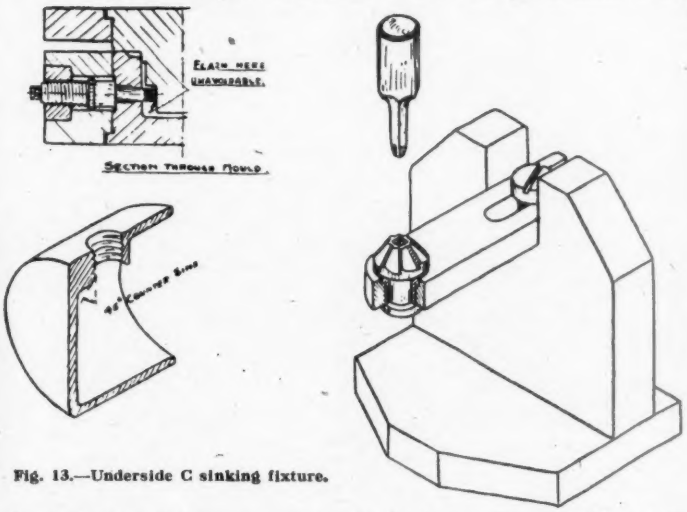


Fig. 13.—Underside C sinking fixture.

having large flutes are run out at high speeds and 60° points are usually employed.

Tapping fixtures for side holes in cylindrical components consist of a simple Vee block or snug ; holes are always drilled larger than standard tapping size, and often taps are chromium plated to increase life.

Flash removal from the inner faces of cored side holes, often create a difficulty, which may be overcome by mounting on a horizontal bar, in suitable bearings a countersink cutter having a square hole through the centre. This to be arranged so that the moulding in question may pass over to bring the cored hole in contact with the cutter. With a suitable square shaft in a driller chuck, the cutter may easily be turned, and de-flashing carried out. See Fig. 13.

Turning and milling operations are occasionally required, the only difficulty met here is the abrasive action of the material. Tungsten carbide tips are very suitable for two flute cutters and single point tools used in these operations.

Articles which may be turned on a mandrel two or more at each

setting should not be moulded with vertical flash if avoidable or unless a de-flashing operation is contemplated prior to turning.

Gauging, viewing, spraying, testing, painting, etc., all take their places but it is seldom that any finishing operation may be termed complicated.

Conveyer systems applied to moulding in a broad sense are not particularly successful, but if a department is laid out specifically for one production job, then a different aspect appears.

Here a short belt conveyer from press to each finishing operation leads towards high efficiency but it is advisable to make a reserve of unprocessed mouldings before starting up the conveyor. This will cover contingencies such as press failures rejected mouldings, etc.

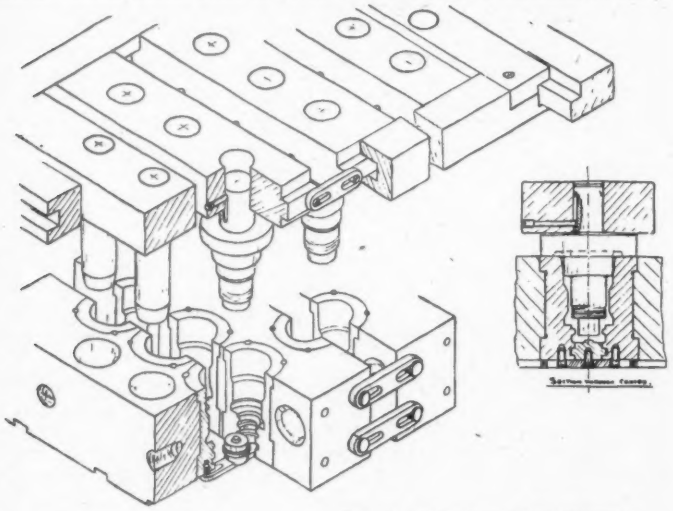


Fig. 14.—Sliding punch split mould

Conclusion.

At this stage we have covered, somewhat inadequately, the general outlines of plastic production by pressure methods, which compared with engineering establishments is straight forward and simple. In its simplicity lies its merit and future development in a large sphere is certain. Revolutionary methods of heating, which considerably reduce the pressures required for moulding, are beyond the experimental stage. Along these lines alone there is abundant scope.

That, however, is outside the limits of this paper, so we will conclude by expressing the opinion that Plastics have a great future.

THE RESEARCH DEPARTMENT ACTIVITIES

QUARTERLY REVIEW—2

Turning Tests.

Rough and finish turning tests within the range outlined in Review No. 1 have been continued throughout the past quarter. The private reports issued included two covering extensive investigations for Government Departments. Further progress has also been made on the general report to be published at the end of the year.

Drilling Tests.

The main series of drilling tests on mild steel is now finished and progress has been maintained on alloy steels, cast iron and non-ferrous alloys. A number of private reports on drilling tests have been issued. Considerable progress has been made on a special series of tests and a report entitled "Practical drilling tests" will be published during the next quarter.

Milling Tests.

Only a few milling tests have been carried out during the past quarter, but considerable progress has been made on the preparation of equipment for an extensive series of negative rake milling tests. This equipment is now almost complete and the tests will be commenced in the very near future.

Performance of Cutting Oils.

A number of drilling tests and turning tests for comparing the performance of cutting oils have been completed during the past quarter.

Surface Finish.

Tests covering the practical application of surface finish measurement have been continued.

New Equipment.

The most interesting piece of new equipment made available during this quarter is a small capacity drilling dynamometer.

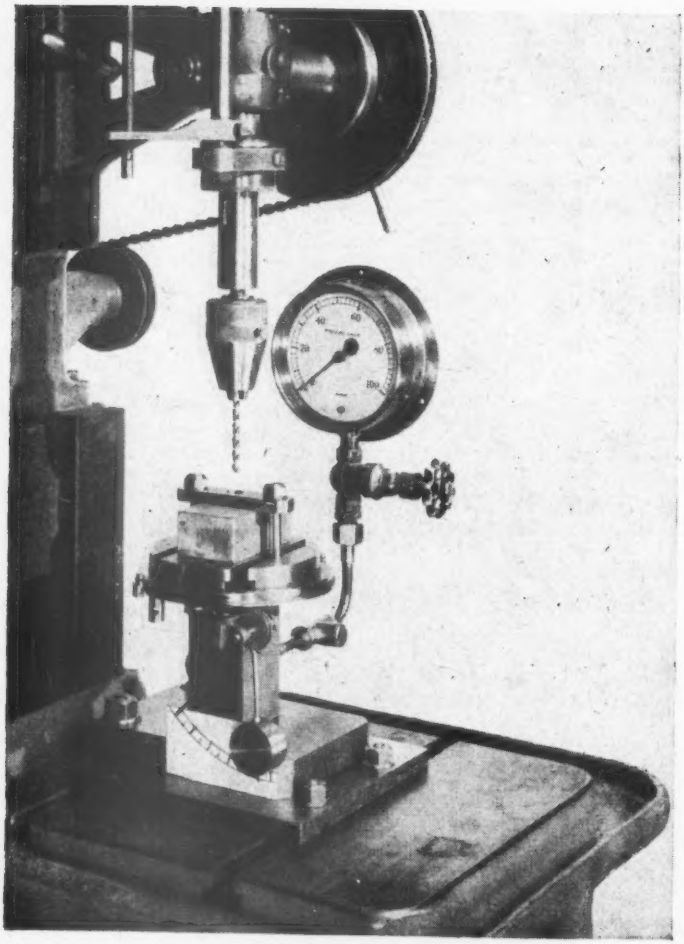


Fig. 1

This dynamometer, shown in Figs. 1 and 2, has been designed primarily for use in tests on non-ferrous materials with drills up to ½ in. diameter, but can also be used with suitable modifications, for tests on ferrous materials.

Fig. 1 shows the general appearance of the apparatus, and a simplified arrangement drawing is shown in Fig. 2. The whole dynamometer is carried on its base A (Fig. 2) which in turn is held on the drilling machine table by means of T-bolts. On A is a cylinder B in which moves the piston C: the cylinder is filled

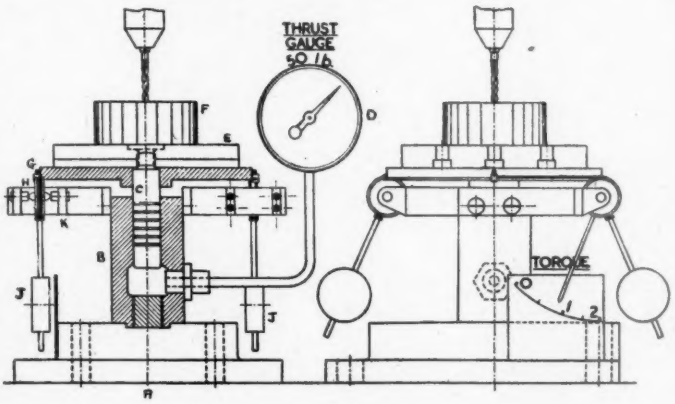


Fig. 2

with oil and connected by a short pipe to the pressure gauge D. The upper end of the piston C is screwed into the table E, on which is clamped the workpiece F.

The table is restrained from turning freely by the two light cords G passing over the pulleys H and anchored to the pendulums J.

When drilling is commenced the resulting cutting forces cause thrust and torque loads on the workpiece drilled and consequently on the table E. The thrust and torque are measured simultaneously as follows:

The thrust tends to force the piston C downwards and increases the oil pressure in the cylinder. This increase in pressure is recorded by the gauge D and, since the area of the piston C is known, the total pressure on the piston (i.e. the drill thrust) can easily be calculated, after due allowance has been made for frictional and other losses.

The torque exerted by the drill on the specimen and the table E is resisted by the cords G. Since the pulleys H are mounted on the pivot bearings K, tension in the cords will rotate these pulleys and raise the pendulums J. The movement of the pendulums, measured on the scale L indicates the magnitude of the drill torque.

The range of the instrument can be altered to suit ferrous materials by using heavier weights and a gauge suitable for higher pressures.

D. F. GALLOWAY,
Deputy Director.

14*th October*, 1944.

Research Department: Production Engineering Abstracts

(Prepared by the Research Department.)

NOTE.—*The Addresses of the publications referred to in these Abstracts may be obtained on application to the Research Department, Loughborough College, Loughborough. Readers applying for information regarding any abstract should give full particulars printed at the head of that abstract including the name and date of the periodical.*

HEAT TREATMENT.

Working with Quenching Fluids. (*The Machinist, 14th October, 1944, Vol 88, No. 27, 12 pp., 10 figs.*).

Principles of quenching. Tempering. Types of quenching fluids, water, sodium-hydroxide solution, acid and alkali solutions, brines, oils, air, heated salt and metal baths, etc. Quenching practice: quantity of quenching fluids required, temperature of the bath, surface condition of quenched part, agitation of the quenching bath, immersion methods, size of quenched parts, interrupted quenches, preventing distortion, and quenching surface-hardened steels. Quenching equipment.

Heat Treatment of Gears, by R. Hamilton Watt. (*Power Transmission, October, 1944, Vol. 13, No. 153, 3 pp.*).

The principles of heat treatment are first described for carbon steels, and the modifications introduced for alloy steels are then indicated. Forms of hardening equipment are compared (e.g., gas, electric and oil fired furnaces) from the operational and economic aspects. Since casehardening is the necessary form of treatment, the remainder of the article describes the carburising and core refining processes with a brief note on nitriding.

Fundamental Principles and Applications of Induction Heating. (*Sheet Metal Industries, October, 1944, Vol. 20, No. 210, (9 pp., 14 figs.*).

Part III. Choice of frequency equipment. When choice of frequency has been made the equipment must be chosen. This part covers the sources of high-frequency current: (a) The motor-generator. (b) The spark-gap. (c) The valve oscillator method.

ACCOUNTING AND ADMINISTRATION.

The Fallacy of the Economic Batch Size, by D. Tiranti. (*Machine Shop Magazine, October, 1944, Vol. 5, No. 10, 4 pp.*).

Setting-up time can be reduced by machining a large batch instead of several smaller ones. This does not necessarily give a monetary saving, since direct saving of setting expenses may be more than off-set by "hidden" disadvantages such as, cost of material tied up in undelivered goods, rent of storage space and unbalanced machine loading.

ELECTRICAL ENGINEERING.

Electronics in Review, by W. D. Cockrell. (*Machine Shop Magazine, October, 1944, Vol. 5, No. 10, 5 pp.*).

The author regards the electronic tube as an engineering tool. He describes briefly several types of electronic device including cathode ray tubes, photo tubes, thyratron and ignitron tubes. Numerous applications of these tubes are given such as : the control of electric motors ; the timing, heat and current control of resistance welding machines ; the timing of photographic printing, plastic press operations, induction heating cycles, branding, and other short heating cycles ; and inspection, gauging, counting, and sorting.

EMPLOYEES AND APPRENTICES.

Some Aspects of Reinstatement, by Sir Godfrey H. Ince. (*Industrial Welfare and Personnel Management, September-October, 1944, Vol. XXVI, No. 296, 5 pp.*).

An address by the Director General of Man Power forming a general survey of the problem. Items dealt with include : the importance of cooperation, the obligation of the employer; deferring reinstatement; dismissing other workers; to make room for returning men ; the seniority rule where an employer has during the war engaged a number of work-people for the same job ; the job that " would have been applicable " ; settlement of disputes ; the spirit of the act ; and resettlement officers.

Industrial Relationship after the War, by E. H. Gilpin. (*Industrial Welfare and Personnel Management, September-October, 1944, Vol. XXVI, No. 296, 4 pp.*).

The necessity for unity in peace. Basic facts.: (1) Industry exists to serve the community and its primary duty is to the consumer. (2) The well-being of those engaged in it is a primary charge upon its activities, preceding profit to the investor. (3) This well-being depends on the stability of the business being maintained by adequate reserves. Selection of directors. Function, of a Works Council, in relation to the production committee, trades unions and management. The Freedom of Economic Citizenship. Assessing wage demands with the aid of reports by independent accountants and management consultants. The question of profit-sharing or co-partnership. A Ministry of Industry.

Joint Consultation, by Mary Boutflower. (*Industrial Welfare and Personnel Management, September-October, 1944, Vol. XXVI, No. 296, 4 pp.*).

Reports on a survey recently undertaken by the Industrial Welfare Society, which included the following industries : engineering, chemicals, electrical, food, foundries, textiles, clothing, laundries, glass and potteries On the whole, the statements received seem to suggest that even in firms where JPC's are working smoothly, the achievements, in so far as they relate to production, have been very limited. Various reasons are advanced for the poor results. The following are the most common : (a) the workers are not yet sufficiently educated in committee technique to be able to take full advantage of a J.P.C. ; (b) managements do not make full use of J.P.C.'s because they are not yet convinced of their value—that is to say cooperation is not two-way as it should be ; (c) the number of technical questions which can be raised is very small because production plans are strictly limited by wartime orders, limitation of supplies, etc., and there is very little scope for variation in production methods, with the result that many suggestions from the committees have to be turned down as impracticable : (d) workers have not sufficient knowledge nor a sufficient sense of responsibility to take part in management

through the J.P.C. machinery. There is also a tendency to discuss welfare rather than production problems. To say that achievements on the whole have been limited on the production side is not to belittle the work done in many instances by individual J.P.C.'s in the munitions industry. The future of joint production machinery is discussed at length.

L.M.S.—The Training of Apprentices, by E. J. Larkin. (*The Engineer, 22nd September, 1944, Vol. CLXXVIII, No. 4628, 4 pp., 3 figs.*).

The progressive system of workshop training was first introduced in the Derby locomotive works in 1932. This particular system deals primarily with two classes of apprentices, viz.: (1) The trade apprentice, and (2) the engineering apprentice, who is a selected trade apprentice or one who is recruited direct from a secondary or public school. The objects of the progressive system, its fundamental principles and working in practice are described.

(*A short account of this scheme also appeared in "Engineering" for 6th October, Vol. 158, No. 4108*).

Training for the Metallurgical Engineering Industries. (*Brochure, 1944, 35 pp., B.N.F., Serial 27,424*).

Outlines of Birmid Apprenticeship Scheme, for a five-year training in various branches of metallurgical engineering, with an opportunity of further specialised training in selected cases.

(*Communicated by the British Non-Ferrous Metals Research Association*).

FOUNDRY.

Prefill Injection System for Diecastings, by F. C. Ziesenheim. (*Iron Age, 13th July, 1944, Vol. 154, No. 2, 4 pp.*).

System is claimed virtually to eliminate porosity, resulting in greater strength and utility of non-ferrous die-castings of a size hitherto considered beyond range of commercial production. Mention only of production of die-cast parts in Al-Si-Cu and Al-Si.

(*Communicated by the British Non-Ferrous Metals Research Association*).

The Production of Aluminium Gravity Die-Castings. by John Vickers. (*Machinery, 26th October, 1944, Vol. 65, No. 1672, 4 pp., 4 figs.*).

A high degree of mechanisation has been introduced in the Rolls-Royce die-casting foundry for the purpose of maintaining maximum output. This abstract of a paper read before the Institute of British Foundrymen gives a general description of the equipment and methods used for melting, casting and inspecting.

MACHINE ELEMENTS.

Map Reading for Production Engineers. (*Production and Engineering Bulletin, October, 1944, Vol. 3, No. 23, 7 pp., 10 figs.*).

This article is principally concerned with the "Leete" system for making isometric drawings of machine components. The system makes use of special scales, set squares and tables for rapid production. Brief reference is also made to the "Tharratt" and "Trimetric" systems.

Three Dimensional Drawings Speeded by Photographic Method. (*The Iron Age, 13th July, 1944*).

In preparing pictorial or three-dimensional drawings for the shop an ordinary flat machine drawing is photographed at an angle which gives a distorted reproduction. This reproduction is used as a base on which the draughtsman fills in the other two dimensions or faces with 50 to 80% saving in time over the drawing of a perspective by ordinary methods. The method of doing this work, and an apparatus embodying a camera for doing it are described.

(*Communicated by Machine Shop Magazine*).

Anti Friction Bearings, Part III, by W. J. Roberts. (*Power Transmission, October, 1944, Vol. 13, No. 153, 5 pp., 3 figs.*).

The re-metalling processes, equipment, procedure, tests, common faults, fitting and finishing, are dealt with in considerable detail from the practical viewpoint.

Journal Bearing Design as Related to Maximum Loads, Speeds and Operating Temperatures, by S. A. McKee. (*Power Transmission, 15th October, 1944, Vol. 13, No. 153, 5 pp., 3 figs.*).

The problem of bearing design is complicated by the fact that a journal bearing is not only required to support its load under all conditions of operation but also must often provide means for dissipating the heat generated in shearing the film of lubricant. Rational methods for the design of bearings operating under constant moderate loads and speeds have previously been published and two methods for assuring conditions for " thick-film " or stable lubrication suggested are based upon the evaluation of the minimum thickness of the oil film by means of theoretical hydrodynamical relations, the other based upon dimensional analysis. These are briefly discussed. In numerous applications the modern trend towards higher speeds and loads has reached the point where the factors affecting bearing tempertature are as important as those relating to proper film formation. A rational basis for the design would seem to be the determination of the maximum allowable loads and speeds predicated upon two primary considerations : (1) that the bearing shall always operate in the region of stable lubrication, and (2) that the operating temperature of the bearing shall never exceed some fixed value. This requires a knowledge of the factors affecting both the rate of heat generation, and the rate of heat dissipation. The author develops a method and shows its application to design. A numerical example shows that, though complicated, the method is quite feasible. In conclusion the author states that with the data now available it will provide only a rough approximation of bearing capacity. Steps required before it could be applied more rigorously are a complete investigation of the frictional characteristics of journal bearings and a comprehensive study of the factors affecting heat dissipation for various types of bearings applications.

Friction of Ball and Roller Bearings, Parts I, II, by L. Rosenfield. (*Engineering, 29th September, 6th October, 1944, Vol. 158, No. 4107, 4108, 4 pp., 18 figs.*).

An abridged report of the Automobile Research Committee of the Institution of Automobile Engineers. While calibrating an apparatus for bearing tests it became necessary to make tests on the friction of the two roller bearings supporting the shaft. Published information on the various factors affecting friction in anti-friction bearings was collected, but such information is scarce

and not readily available, so that the publication of a separate report on the collected information, together with the results obtained in the Research Department laboratories was considered to be justified. Total frictional resistance is composed chiefly of rolling friction due to the elastic deformation of the rollers and races and sliding friction due, firstly, to different speeds of rolling of points in simultaneous contact, and, secondly, to the tendency of the rolling elements to rotate about an axis not parallel to that of the shaft. The report considers the relative effects of these and other factors for different types and proportions of bearings as found by different investigators and then describes the tests carried out in the I.A.E. Research Department.

Splash Oiling Sytem, by E. V. Paterson. (*Mechanical World, 22th October, 1944, Vol. 116, No. 3016, 4 pp., 3 figs.*).

Splash oiling is the most suitable way of lubricating a number of bearings which are all contained in the same oil-tight casing. The author describes splash systems for air compressors, gas engines and steam engines.

Circulation Systems, by E. V. Paterson. (*Mechanical World, 27th October, 1944, Vol. 116, No. 3017, 5 pp., 7 figs.*).

After a general description of gravity feed and force feed methods for bearings, the article deals mainly with systems for gas, oil and steam engines, and turbines.

MACHINING AND MACHINE TOOLS.

How Can Machine Tools be Improved ? by H. T. Johnson. (*The Machinist, 7th October, 1944, Vol. 88, No. 26, 2 pp.*).

A questionnaire by the Director of Standards, General Motors Corporation. The answers given are a consensus of opinion of plant engineers, etc.

The Application of Hydraulic Power to Machine Tools, by G. Butler. (*Machine Shop Magazine, October, 1944, Vol. 5, No. 10, 6 pp, 7 figs.*).

The article first describes the features of these arrangements : simple circuit with constant delivery pump ; circuit in which reversal is obtained by a reversing valve of the piston type ; cylinder compounding for speed range variation ; and circuit with valve gear to give differential action. Short notes on the design of pipe lines and oil sumps are given. In conclusion the author deals with the application of hydraulic power to the shaper, stressing the points which must be considered if advantages over mechanical drive are to be gained.

Review of Negative Rake Milling, by J. V. Ellis. (*The Machinist, 28th October, 1944, Vol. 88, No. 29, 2 pp., 3 figs.*).

This brief article forms a useful summary of present information including data from British and American sources.

Cemented-Carbide Cutting Tools. (*Machinery, 12th October, 1944, Vol. 65, No. 1670, 8 pp., 10 figs.*).

Further results obtained by Joseph Lucas, Ltd. Results will be considerably improved by the use of a finely finished tool, even on heavy cuts. On light cuts fine finishing will extend tool life by three to five times that of the ground tool. The method of finishing tools is by lapping them with diamond-impregnated wheels, of the Wickman-Neven type, used at a peripheral speed of 6,000 feet per minute, and a finish of 2 to 3 micro-inches can be obtained. It is

customary to use turning tools in which chip breakers have been ground and dimensions are given. The performance of tungsten carbide is compared with high-speed steel with the aid of life curves, the derivation of the latter being described. It is felt that there is considerable scope for the use of cemented-carbide tools on steel components when using automatic screw machines and multi-spindle automatics, and objections commonly raised are dealt with. Milling cutter design is discussed with reference to type and size of cutter, H.S.S. or carbide tips, positive or negative rake and degree, minimum tooth spacing, feed per tooth and tool pressure involved to give finish required in component, maximum number of teeth engaging job at one time, r.p.m. of cutter and table feed. A typical example of tests taken on a 4K Milwaukee vertical milling machine is given : cutting mild steel at 1249 f.p.m., feeds ranged up to 40 in. per mun., powers up to 16½ H.P., and material removed up to 16 cu. in. per min. Typical examples of negative rake milling in the Lucas demonstration bay are then described.

Diamond Powder and its Applications. (*Machinery, 12th October, 1944, Vol. 65, No. 1670, 3 pp.*).

General features. Production methods. Diamond powder in the preparation of diamond-tipped tools and operations on jewel bearings, quartz, knife edges and crystal. Optical glass working. The lapping of sintered carbide-tipped cutting tools.

Machining of Light Alloys with Diamond Tools. (*Light Metals, September, 1944, Vol. 7, No. 80, 7 pp.*).

Summarises the advantages of diamond as a cutting material, referring in particular to the machining of Al alloy pistons. Bibliography.

(*Communicated by the British Non-Ferrous Metals Research Association*).

Producing Bevel Gears on Standard Gear Hobbing Machines. (*Mechanical World, 13th October, 1944, Vol. 116, No. 3015, 1 p., 2 figs.*).

A translation from a German technical paper describing the production of bevel gears on a standard gear hobbing machine. An attachment is fixed to the table of the hobbing machine and the teeth are generated by a form milling cutter and continual and automatic indexing. The success of this method depends on the correct selection of the profile of the milling cutter, and the procedure is indicated.

CHIPLESS MACHINING.

The Technique of Deep Drawing as applied to Automobile Pressings, Part II, by E. N. Salmon. (*Sheet Metal Industries, October, 1944, Vol. 20, No. 210, 3 pp., 2 figs.*).

Part II. A suitable material is required to perform the following broad functions : Stretch, stretch and compression combined, work harden, state of inertness, and these functions are discussed. Materials must also be easily spot welded, afford sufficient "key" for subsequent enamel or paint, and resist corrosion in manufacture or service. The chief consideration from the buying aspect is cost. Another factor is nomenclature, since different interpretations and names are given by steel manufacturers, countries and even by factors, to the same class of steel.

Stretch-forming Extruded Shapes. (*Machinery, 19th October, 1944, Vol. 65, No. 1671, 7 pp., 14 figs.*).

Stretch forming operations in plants of the Boeing Aircraft Co., are performed on machines that utilize hydraulic pressure for bending the shapes

around forms, and also cam or lever-controlled devices for imparting the stretching action necessary to hold the formed sections to required outlines without spring-back. Best results have been obtained by stretch-forming Duralumin sections in the heat treated and annealed condition. Generally speaking any shape can be stretch-formed if the material is of uniform section throughout its length at the time of forming, if it is not to be formed into reverse contours, and if the differential elongation will be less than 8%. Typical examples are described, and attention is given to difficulties of distortion, etc., which have to be overcome.

Rotary Stretching. (*Aircraft Production, October, 1944, Vol. VI, No. 72, 3 pp., 10 figs.*).

A Goodyear machine for manipulation of extrusions and other formed sections.

Bending Preformed and Extruded Sheet-Metal Sections, by Thomas T. Tobin. (*Machinery, 5th October, 1944, Vol. 65, No. 1669, 7 pp., 7 figs.*).

The use of wrap-forming and cam-type bending machines on aircraft structural members. The cam-type bending machine is designed for bending preformed sheet-metal sections or extrusions to an arc or other contour in a vertical plane; a typical machine and its operation are dealt with and illustrated examples of jobs which can or cannot be done are given. The wrap-forming machine is used for processes similar to those for which the cam-type bending machine is employed. Its capacity and limitations are somewhat different, and here again machines are described with examples of their applications and limitations.

Chart for Determining Blanking Pressure, prepared by University of California. (*The Machinist, 14th October, 1944, Vol. 88, No. 27, 1 p.*).

There are two practical methods of determining blanking or shearing pressure: by the use of a nomograph, or by use of a simple formula, both being given.

MANUFACTURING METHODS.

The Production of the Merlin Engine, Parts I, II. (*Machinery, 19th and 26th October, 1944, Vol. 65, Nos. 1671 and 1672, 16 pp., 22 figs.*).

Rolls-Royce methods at a Ministry of Aircraft Production factory. Operations on castings including crankcases, sumps and cylinder heads.

The Gipsyqueen II, by J. A. Oates. (*Aircraft Production, October, 1944, Vol. VI, No, 72, 12 pp., 31 figs.*).

Part I. Development of well-known range of de Havilland engines: design features: machining operations on the crankcase, cylinder barrel and head.

Pre-Production Technique, by J. N. Earl. (*Aifcraft Production, October, 1944, Vol. VI, No. 72, 7 pp., 16 figs.*).

Efficient organisation can do much to reduce the time interval between the completion of a new design for an aircraft and the beginning of production. The establishment of accurate profiles and dimensional data before production actually commences prevents many assembly difficulties and consequent rectification of tooling equipment. This article reviews lofting practice and template re-production as practiced by Westland Aircraft Ltd. It deals with laying out of the mould-loft, its technical function, methods, template reproduction and obtaining dimensional data.

MATERIALS, MATERIAL TESTING.

The Identification and Handling of Ferrous and Non-Ferrous Scrap, by D. G. P. Paterson. (*Sheet Metal Industries, October, 1944, Vol. 20, No. 210, 3 pp.*).

Scrap may be segregated if, before changing over to another material, the machine is thoroughly cleaned and freed from turnings and chips of the preceding metal. Otherwise, identification, of mixed scrap must be made. For non-ferrous metals various methods of rapidly identifying scrap metal have been suggested, e.g. blowpipe and chemical tests. Efficient segregation of steel scrap is vital if alloying elements are to be recovered. Methods include spot tests, spark testing, the use of a " Spekker Steeloscope," and magnetic sorting. Assuming efficient segregation, the subsequent use of scrap metal presents its own peculiar problems. Cleanliness is essential and it is not economical to feed long curly turnings directly into the melting furnace. References are given.

Indentation Hardness of Plastics (and Metals), by L. Boor. (*A.S.T.M. Preprint 91, June, 1944, 23 pp., B.N.F. Serial 27, 418*).

This is really an investigation of the extension of the application of the Rockwell hardness tester to plastics, but includes time-indentation curves on brass, Cu and mild steel (all annealed), Duralumin, Pb-Ca-Ba, Al, cast Sb, cast Zn, Zn-base die-casting alloy and Pb-Ca.

(*Communicated by the British Non-Ferrous Metals Research Association*).

Factors Affecting Hardness Relationship in the Range 50 to 250 Brinell, by R. H. Heyer. (*A.S.T.M., Preprint 95, June, 1944, 18 pp., B.N.F. Serial 27, 419*).

This paper continues author's work undertaken for the Joint A.S.M.—A.S.T.M.-S.A.E., Committee on Hardness conversions below about 250 Brinell. Effect of work-hardening capacity; importance of close control of duration of application. A method based on observation of the contour of hardness indentations is described for constructing general hardness conversion tables of improved accuracy. Considers hardness-tensile strength relation ships. Materials investigated include Cu and alloys, Al and alloys, Mg alloys, and steels.

(*Communicated by the British Non-Ferrous Metals Research Association*).

MEASURING METHODS, APPARATUS AND INSPECTION.

The Microscope as an Aid to the Engineer, by J. F. Driver. (*Machinery Lloyd, 14th October, 1944, Vol. XVI, No, 21, 10 pp., 20 figs.*).

A short up-to-date review of available equipment including: a simple instrument for examining fractured surfaces, cutting edges and defects on finished surfaces; binocular microscopes for machined work, samples of welding, galvanising, paints and other protective surface finishes, joint packings and raw materials generally; tool-room microscopes; Brinell microscopes; polarizing microscopes; metallurgical (including projection type) microscopes; and the electron microscope.

Quality Control by Limit Gauging. (*Production and Engineering Bulletin, October, 1944, Vol. 3, No. 23, 5 pp., 5 figs.*).

In this article, contributed by the Ministry of Supply Advisory Servic on Quality Control, it is briefly explained how quality control by gauging may be applied.

Accurate Inspection of Magnesium Alloy Castings. by R. Taylor. (*Iron Age, 13th July, 1944, Vol. 154, No. 2, 4 pp.*).

Discusses correlation of radiography, metallography and machining operations to remove defects.

(*Communicated by the British Non-Ferrous Metals Research Association*).

PHOTOGRAPHY AND RADIOGRAPHY.

General Discussion on Radiological Testing (North East Coast Institution of Engineers and Shipbuilders), by Sir. L. Bragg, S. F. Dorey, V. E. Pullin and H. Harris. (*Trans. N.E. Coast Inst. Eng. Ship., July, 1944, Vol. 60, No. 8, 19 pp., Discussion and correspondence D 169-186*).

The following introductory contributions were made by the above authors: (1) The Mechanical Strength of Metals; (2) Radiology in Engineering; (3) Some Remarks on Radiography and in particular Weld Radiography; (4) Radiology in Relation to Welding. Some of the discussion refers to the subject as a whole, some to weld radiography.

(*Communicated by the British Non-Ferrous Metals Research Association*).

PLASTICS AND POWDER METALLURGY.

Extrusion Process for Thermo-Plastic Moulding. (*Engineering, 13th October, 1944, Vol. 158, No. 4109, 2 pp., 5 figs.*).

A new method of moulding thermo-plastic materials has been developed for the manufacture of mouldings in polythene. It consists of forcing the material in a fluid state, by means of a screw extruder, into a closed mould, a suitable nozzle being formed on the end of the extruder barrel. Since the material is forced into the mould by a screw, there is no limit to the size of the mould used so long as the fluid is applied to the screw. Pressure between 200 lb. and 400 lb. per square inch is employed. Actual machines are described.

Presses and Processes for Metal Powder Products, by E. V. Crane and A. G. Bureau. (*The Iron Age, 29th June, 1944*).

This article traces briefly the historical background of the subject. The preparation of powders is dealt with and mention is made of avoidance of arching or cavitation in a powder mass. This article deals also with the production of porous components such as bushings, and with solid compression problems. Different types of presses are discussed and indications are given of their suitability for the work. Dies and heat treatment are also subjects that are discussed.

(*Communicated by Machine Shop Magazine*).

SHOP MANAGEMENT.

A Basis for Fatigue Allowance Evaluation, by S. Bloye Dipple. (*Mechanical World, 13th October, 1944, Vol. 116, No. 3015, 3 pp., 1 fig.*).

Part III. Comparison of two methods of selection of operator's times taken and ratings. Times must be adjusted to allow for fatigue due to;

strenuousness and dexterity; closeness of attention; posture; noise, eye strain; and conditions. Minimum and maximum allowances, with tables of variables in each category for typical jobs.

Tool-Rooms and Incentives, by W. F. Walker. (*Sheet Metal Industries, October, 1944, Vol. 20, No. 210, 7 pp., 3 figs.*).

To permit successful operation of a piecework system, the following are required: (1) a ratefixer; (2) a system of planning; (3) a system of standards; (4) a wage payment system; and (5) efficient control. The ideal ratefixer for a tool-room is an all-round toolmaker. Troubles often experienced, and the ratefixer's approach to them, are considered. In a tool-room of moderate size, the ratefixer would probably also be responsible for the actual planning of all the work. Many valuable and costly hours can be saved by careful manufacture of press tools, drill jigs, milling fixtures, capstan tools, etc. The wage system suggested for operation in a tool room is the " Rowan " premium bonus scheme, which is described with the aid of examples.

SMALL TOOLS.

Cemented Carbides. (*Automobile Engineer, September, 1944, Vol. XXXIV, No. 453, 7 pp., 9 figs.*).

The manufacture of Wimet for cutting tools and other purposes is described. The main raw material used in the manufacture of cemented carbides is pure tungstic acid or tungstic oxide which has first to be converted to tungsten metal powder. Conversion is carried out by heating to about 900 deg. C. in an atmosphere of pure dry hydrogen. After the tungsten powder has been produced, slightly more than 6 % lamp-black is mixed with it, and the mixture heated to about 1,500 deg. C. in a hydrogen atmosphere for several hours to form tungsten carbide. Cobalt metal powder is prepared for use as a matrix and after preparation accurately weighed charges of tungsten and cobalt, with slight additions of titanium for some grades, are thoroughly mixed in ball mills. The operation takes from one to three days according to the size of grain that is required. Great care is taken to ensure that the various powders conform to very rigid specifications and some of the tests are described. Processing from the powder mixture to the sintered carbide is generally carried out in five stages: (1) Pressing. The prepared powder is pressed in steel dies under hydraulic pressure to give a block of the desired shape and size, in either hand-filled or automatic hopper-fed dies. (2) Dewaxing. Paraffin wax has to be used as a lubricant in pressing, and must be removed by being heated to 400 deg. C. before (3) Pre-sintering. Presintering is done in furnaces between 750 and 1000 deg. C. and hydrogen and changes the material into a form which can (4) be handled and cut with an elastic wheel, turned in a lathe, ground, milled or drilled, according to the final shape required. (5) Final sintering is carried out at temperatures of the order of 1,500 deg.C. After this hardness and specific gravity tests and dimensional checks are carried out. Tool production is next dealt with, including methods of brazing. Free-hand grinding is employed on the cutting angles of standard lathe tools using machines equipped with adjustable rests and Silicon carbide wheels. Increasing use is now being made of cemented carbides for form and other special tools. An optical profile grinding machine is used and this is described. A well-equipped department is devoted to the practical testing of lathe tools, milling cutters, etc., and at present investigations on negative rake milling and turning are being carried out.

SURFACE AND SURFACE TREATMENT.

The Finishing of Light Alloys ; a Topic of Post-War Interest, by L. Whitby. (*Oil and Colour Trade Journal, 5th May, 1944, Vol. 105, No. 2377, 2 pp.*).

Summarises main points of author's paper (and discussion) to London Section of Oil and Colour Chemists' Association; value of anodic oxide coatings on Al (abrasion resistance and suitability as antifriction surfaces) ; their impregnation with organic dyestuffs and inorganic pigments ; paint coatings on Al and Mg alloys.

(*Communicated by the British Non-Ferrous Metals Research Association*).

Zinc Plating of Large Aircraft Structures, by M. Sanz. (*Iron Age, 15th June, 1944, Vol. 153, No. 24, 7 pp.*).

Describes equipment and technique used for this purpose ; cleaning and passivating practices. Gives also data on changing tanks from Cd to Zn plating. Much of the information herein was presented at the recent annual meeting of the American Electroplaters' Society.

(*Communicated by the British Non-Ferrous Metals Research Association*).

The Pickling of Steels ; A Survey of the General Principles, Part II, by T. P. Hoar. (*Sheet Metal Industries, October, 1944, Vol. 20, No. 210, 3 pp.*).

Continuing the survey of the theory of the process, the following are discussed : Anodic pickling ; cathodic pickling ; the pickling of alloy steels ; and recent developments. 100 references are also given.

WELDING AND JOINTING.

The Welding Department, by H. Marquand. (*Welding, October, 1944, Vol. XII, No. 11, 6 pp., 9 figs.*).

Part II. Flash welding. Materials successfully butt-welded. Butt welders for general purposes. Welding shop organisation for relatively small businesses. The design department. Responsibility for the success of the finished product ; production of working drawings ; training of draughtsmen.

Welding Fabrication, by J. A. Dorratt. (*Mechanical World, 13th October, 1944, Vol. 116, No. 3015, 5 pp., 8 figs.*).

Fabrication by welding has now become so specialised that this work cannot be well done without shops specially equipped for the work. The equipment should include guillotines and flame-cutting machines for plate preparation since this controls the speed of assembly, speed of welding and the amount of weld distortion to a considerable degree. Other important machines are: bending and folding machines ; the hydraulic press for both hot and cold stock with and without special dies ; and bar and plate rolls. Without them the full potentialities of fabrication cannot be realised. In the layout of the welding shop one of the most important things is the provision of adequate prepared assembly areas with a section of the shop floor covered with slotted cast iron bed plates. Detail assemblies are desirable for handling reasons. It is now common to have pre-machined parts in a structure and the correct use of this technique greatly facilitates the final machining operation, or in some cases even eliminates it altogether. Much sub-assembly work is done entirely on welding manipulators. Full use is made of positioning for both

assembly and welding ,and dimensional accuracy can be obtained more readily. The whole job may be finished by complete assembly and welding as it rests in the horizontal position, or the mounting of the tack weld assembly on a manipulator for final welding. If the amount of welding is considerable the second method will prove the cheaper. Although arc welding is probably the most important process of fabrication some thought should be given to others such as flash butt welding. This is the cheapest welding method as it requires the simplest joint preparation, minimum power consumption and no expensive filler metal or electrodes, but whether its use for general work is appreciated as much as it deserves is a little doubtful. The latter part of the article deals with marine engineering applications. Watertube boilers require welding with general purpose electrodes for the framework and with special electrodes and technique for the drums : the methods are briefly indicated. Welding is also used in Scotch boilers for the combustion chamber wrapper plate butts and the butts on the back and front of the boiler. The welding of stays in place of screwing has also been introduced. An application to oil engine structures is shown which is a good example of the difference between cast iron and fabricated steel practice. The fabrication of condensers is mentioned. The cost of tooling and the quantity required determines whether complete jig assembly is feasible, and two examples where this is so are described.

Arc-Welded Aircraft Jigs and Fixtures. (*Aircraft Engineering, October, 1944, Vol. XVI, No. 188, 3 pp., 6 figs.*).

This article is taken from a paper submitted by the Senior Tool Engineer, Boeing Aircraft Company, for the competition organized by the James F. Lincoln Arc Welding Foundation, and deals with the use of arc welding to eliminate expensive machining operations in the manufacture of aircraft jigs. The nature of aircraft tooling and its evolution are indicated. With the increase in the orders for aircraft, there were three objectives in developing a new fixture design procedure.:

1. To minimise machining.
2. To minimise tools required for jig fabrication.
3. To minimise time required for jig fabrication.

The problem was to make jigs with a tolerance of plus or minus 0.010 inch and this was accomplished by a planned use of arc welding. For large jigs a spherical bushing is a universal fixture and its application is shown. For minor jigs special fittings have also been evolved and the procedure is described. A cost comparison based on a typical bulkhead assembly jig is given.

The Arc Welding of High Tensile Steels, by H. F. Tremlett. (*Welding, October, 1944, Vol. XII, No. 11, 6 pp., 3 figs.*).

The paper aims at putting before the welder essential metallurgical aspects of the welding of high tensile steels. A scheme is suggested which should enable the welder to select a procedure that would, in the majority of cases, eliminate the risk of cracked joints. Part I covers : alloy steel types ; welding difficulties ; welding of high tensile steels ; metallurgical aspect ; and weld hardenability and cracking tests.

Low Temperature Welding of High Speed Steel. (*Machine Shop Magazine, October, 1944, Vol. 5, No. 10, 4 pp.*).

The repair of broken high speed steel tools and the fabrication of new ones by the use of low-temperature copper-base brazing alloys. Fixture

design. Individual fluxes and fluxing. Service record of tools repaired including broaches, drills, reamers and cutters.

Hard-Surfacing by Welding parts I and II, by C. R. Wittemore. (*Can. Met. and Met Ind., June, 1944, Vol. 7, No. 6, July, 1944, Vol. 7 No. 7, 10 pp.*).

Part I describes the welding processes (oxy-acetylene and electric arc) used for applying hard surfacing materials, and divides these into five classes, dealing in particular with the Co-Cr-W division of the non-ferrous alloys class. Part II lists the metals and alloys which can be hard-surfaced and gives practical information on the hard-surfacing of steel with each of the five classes of materials.

(*Communicated by the British Non-Ferrous Metals Research Association*).

The Technique of Resistance Welding, by R. Bushell. (*Sheet Metal Industries, October, 1944, Vol. 20, No. 210, 11 pp., 20 figs.*).

A summary of spot welding processes with : data chart for spot-welding mild steel sheet ; recommendations for electrode tips ; calculations of weld energy ; and details of weld timers and multi-head type spot welding machines. Information is also given on the spot welding of alloy steels, brass, silicon bronze, coated materials, and aluminium alloys.

Recent Developments in the Welding of Light Metals, by W. K. B. Marshall. (*Welding, October, 1944, Vol. XII, No. 11, 9 pp., 8 figs.*).

Part I. This deals with the corrosion resistance of light alloy welds ; improvements in gas welding equipment ; the arc welding of aluminium alloys by the metallic arc and carbon arc processes, and magnesium alloys by the " Heliarc " process.

Solders and Soldered Joints, by J. A. Kies and W. F. Roeser. (*Mechanical World, 20th October, 1944, Vol. 116, No. 3016, 3 pp., 8 figs.*).

Abstract of a paper presented to the American Society for Testing Materials. Many of the compositions of low-tin solders included in various specifications differ only in small percentages of elements such as antimony, bismuth, copper, and silver. Since short-time tests are frequently relied on to prove the value or importance of such additions, it is essential to establish procedures which are simple and will yield results which are both reproducible and easily interpreted. The scarf joint was investigated and found to be advantageous for the purpose. Results indicate the effects of speed of pulling, rate of loading, time of supporting the load, temperature, and pre-tinning on the shear strengths of soldered joints. Such data are considered useful in setting up standard procedures for short-time tests of solders and soldered joints, and investigation was made of 13 solders with copper, brass, and steel. The methods of testing and interpreting the results are outlined.

GENERAL.

Post-War Engineering Problems by H. H. Asbridge, M.B.E. (*Machine Shop Magazine, October, 1944, Vol. 5, No. 10, 6 pp.*).

This article is an abridgement of the inaugural address given by the president of the Manchester Association of Engineers. The speaker stressed

the need for technical training coupled with sound workshop knowledge if we are to maintain the prestige of British engineering. It must not be overlooked that many parts of the world have become more industrialised during the war. The industrialists in those countries are up to date—they have started with the plant, knowledge and technical education that we possess to-day. Other subjects dealt with were : the machine tool industry as the foundation of engineering ; the elimination of handwork and the extended role of the machine tool,; and the need for closer relations between users and suppliers of machine tools.

(*Extracts from this Address also appeared in Power Transmission, Vol. 13, No. 153, October, 15*).

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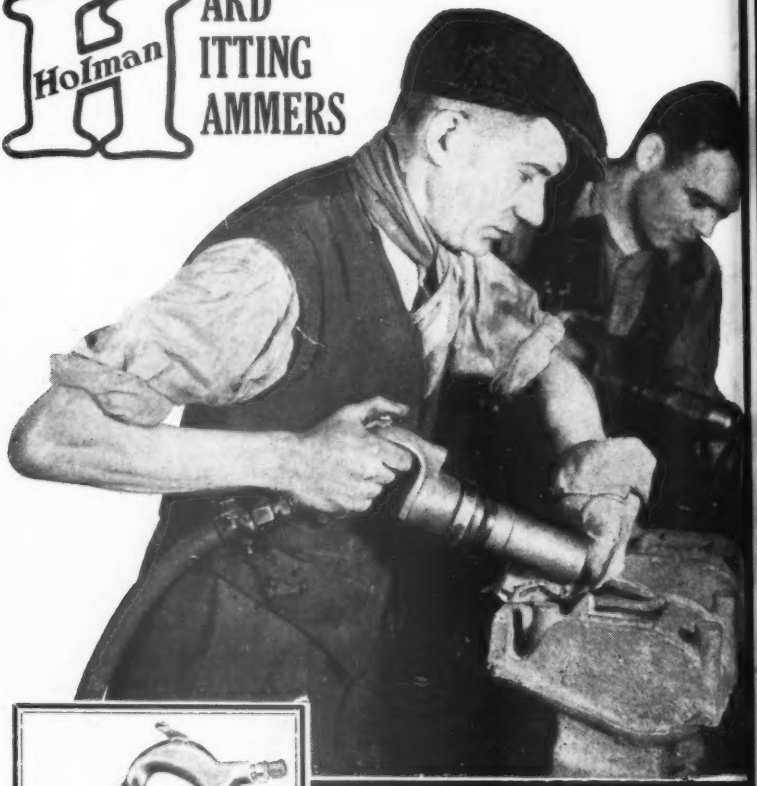

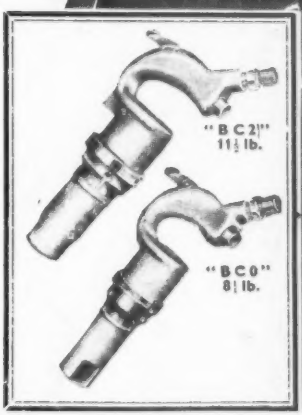

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